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NOVEMBER 1953

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A Journal for All Science and Mathematics Teachers

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School Science and Mathematics

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AND
MATHEMATICS

VOL. LIII NOVEMBER, 1953 WHOLE NO. 469

HOW TO USE THE TEXTBOOK IN SCIENCE TEACHING*

GEORGE GREISEN MALLINSON
Western Michigan College of Education, Kalamazoo, Michigan

Every teacher and every school administrator has at one time or another faced the issue of "the textbook." This issue has been debated from "pillar to post" by enthusiasts who argue at opposite poles. There are those who compare textbooks with the stone tablets on which the Ten Commandments were revealed to mankind. There are others who suggest that they are "Books of Sin" designed to currupt children. The average teacher is subjected to both of these viewpoints and hence, develops ambivalent attitudes toward a concoction of ink and paper which in and of itself is basically harmless.

Of course one might at this point reiterate the old platitude, "fight falsehood with truth." Yet the search for truth concerning the value of the textbook is one that locates little or no pay-dirt. The objective analyses concerning textbooks are few and far between. Those that may be found are couched in "ifs, ands, and buts." It would be a foolhardy man indeed who would thrust his head into the mouth of such an untested lion as is this problem. Yet apparently Demosthenes in the form of your chairman found the foolhardy rather than the honest man. Thus an attempt will be made to summarize and draw interpretations from the facts now available concerning the values of textbooks.

THE TEXTBOOK—"YES" OR "NO"

The question, "Shall we use a textbook," is purely academic. It is an inescapable fact that textbooks have been used in public educa-

* A paper presented to the Michigan Science Teachers Association, at East Lansing High School, East Lansing, Michigan, on April 11, 1953.

tion for almost three centuries, are being used now, and will continue to be used in the future. The question should be rephrased, "Is our use of the textbook justified?" The answer is "Yes." To support such an answer one needs but to go to such an authoritative source as the Forty-Sixth Yearbook of the National Society for the Study of Education[1] for this pronouncement:

"In general, what seems likely to prove most satisfactory is to select a basic textbook that provides a good general outline of the course and the primary text materials which all the class may be expected to study and then to supplement this foundational material with a variety of materials from other textbooks, periodicals, and reference works . . . because any textbook is likely to provide better materials than the average teacher can improvise or assemble in the time and with the facilities available."

A search of the literature reveals only one research investigation that deals directly with the facts implicit in this statement, that undertaken by Stafford.[2]

He performed a study "to compare the effectiveness of teaching biology in one class with a textbook, and in a second with supplemental material only." He built a replica of the textbook that was in use from supplemental materials. The first semester one class was taught with the textbook, and another with the replica assembled from supplemental materials. The groups were rotated the second semester. The gains for both groups for both semesters were measured by means of the Minnesota State Board Examination in Biology for 1947. The differences in amount of gain were not significant. Stafford concluded that the time and effort involved in assembling supplemental materials to replace a textbook are not justified by the results obtained.

The small amount of evidence that is available therefore would tend to support the teacher who makes judicious use of the textbook.

How Does One Find the Best Textbook?

Any sensible teacher, once having a clear conscience about using a textbook, wants to find the best one. The "best" textbook, however, is a relative rather than an absolute judgment. Under any set of standards there are many good textbooks, a vast number of mediocre ones, and a number of ones that are obviously poor.

The selection of a textbook must of course be based on a set of rational criteria. Probably the most suitable of all sets is the one

[1] *Science Education in American Schools.* Forty-Sixth Yearbook of the National Society for the Study of Education, Part II. Chicago: Distributed by the University of Chicago Press, 1947, p. 48.

[2] Stafford, Wayne A., "The Textbook versus Supplemental Material in Teaching Biology," School Science and Mathematics, LII (December 1952), 737–742.

suggested by Vogel.[3] No extensive discussion will be made here of the scale since it is one that is readily available. However there is one item on the scale that deals with the content of the textbook. This item is frequently the one that evokes the greatest amount of criticism and hence will be discussed here.

First, it should be made clear that no author or group of collaborating authors has the right to assume that the contents of a textbook should be based on his or its judgment alone. Such an assumption tends to presuppose that "what is good for the many is known by the few." Any reasonable selection of content should be based on a careful analysis of what curriculum committees, state syllabi, and science teachers indicate might well be included in a science course. The findings of the analysis should be synthesized by a technique similar to the one developed by Curtis.[4] It must be stated that the contents of many of the better textbooks are developed at least to some extent in this way. Hence a careful analysis of the better ones will indicate a marked similarity in content. In all probability eighty-five per cent of the materials found in any one of these better textbooks will be found in the others. The next logical question is, "Where then do they differ?" The answer is two-fold. They differ (1) in the selection of the dissimilar fifteen per cent and (2) in organization.

With respect to the first point there are vastly more topics available than can be taught in any course in science and, of course, included in any textbook. Hence some selection must be made as to which shall be included for the "additional fifteen per cent." In this selective process, the authors are open to criticism since what shall be included is based on the author's interpretation as to what is most important.

With respect to the second point, every book is open to criticism from one or another source in that it does not meet a certain viewpoint as to what constitutes the best organization. Many authors base the organization on a logical assembly of facts much as a jigsaw puzzle is put together, others base it on what has been found by research to be in accord with the psychology of learning, and others organize the material on some vague philosophy that concerns the student's ability "to participate dynamically in a democratic social order." Suffice to say that the opinion here is that the second type of organization is by far the most satisfactory.

How to Use the Science Textbook Satisfactorily

Enough has been said concerning the selection of the textbook

[3] Vogel, Louis F., "A Spot-Check Evaluation Scale for High School Science Textbooks." *The Science Teacher*, XVIII (March 1951), 70–72.

[4] Curtis, Francis D., *A Synthesis and Evaluation of Subject-Matter Topics in General Science*. Boston: Ginn and Co., 1929, Pp. 83.

since at this time the listener may ask justifiably, "So what? When I came into the school, the textbook was already there. I didn't choose it. What do I do? Throw it away?" Or, "So I made a bad guess, and I'm stuck with it. Now how do I make the best use of it?" These are fair questions which demand answers that are not readily provided. However an attempt will be made to make certain suggestions for using any textbook more effectively:

I. *Know Your Textbook.* If any science teacher were given a list of topics that a textbook for one of his courses *might* contain and were then asked to check those that it *did* contain, how correct would he be? Within the last three years in his graduate classes in science methods, the writer presented this problem to over one hundred teachers. The responses averaged about sixty per cent correct. Every teacher checked topics that his book *did not* contain and failed to check those that it *did* contain. Hence it was clear that these teachers were not as familiar with their textbooks as they might have been. Thus, many reading assignments were given without the teachers being clearly aware of what the student was to read, or had read. As a result the student may not have had knowledge of subject-matter that the teacher assumed he had, and may have had knowledge of which she was not aware.

It must be remembered that the book is a tool for contributing to the learning experiences that take place in the classroom. Many however seem to act as though the teacher is the tool for contributing to the understanding of the book. In order then to make use of the tool effectively the teacher must be thoroughly aware of its potentialities.

Such awareness is essential for another reason. Nearly every textbook has errors in it. Even the most careful check cannot eliminate every one. The author may "catch them ahead of time" but between indicating the errors and making corrections on the proof, and the final printing are involved many persons and processes. Editors, layout men and printers are human and they may fail to note the intended corrections. It is up to the teacher to locate these errors and to point them out to the student. Although errors are not desirable, the processes of pointing out such errors or asking the students to locate them may well turn out to be effective learning experiences.

Another weakness is that the presentation may be sufficiently unclear and garbled so that misconceptions are developed in the minds of the students. While an occasional error may be pardoned, it is difficult to justify this latter type of weakness. The teacher should read the book carefully to locate sections likely to cause misconceptions. This is not an easy task since the teacher is likely already to have an adequate perception of the subject-matter. Hence the various points brought up by the author in a certain section may serve

only to reinforce certain aspects of *her* perception of the material. The student however is expected to develop the adequate perception from what appears in the section. Thus, since the material in the section represents an entirely different type of stimulus to the teacher than to the student, the teacher should "step back and view the territory" as much as possible through the eyes of the student. A teacher may be quite surprised to note that the confusion exhibited by the student is not a function of reading ability but rather a function of the expertness with which the material is written.

"Know Your Book" thus becomes a dictum. However, little will be gained if the teacher is aware of the contents and potentialities of the book, but the pupil is ignorant. It is probable that much will be gained if, during the first class periods, pupils are taught how to use the Glossary, the Index and the other teaching aids. The teacher may well during these early periods suggest an exercise such as, "See what your book has to say about the stratosphere," or "To what paragraph does footnote 3 on page 10 refer, and what information is found in this paragraph." Further, the first chapter that usually deals with methods of using the book effectively should be explored thoroughly. Too often this key to the rest of the book is by-passed.

II. *Watch the Vocabulary.* When one discusses the reading level of textbooks one must avoid the narrow view that reading difficulty is merely a function of "vocabulary load." Actually the problem of reading difficulty involves three facets. The first was discussed at the end of the previous section, namely that the material may be poorly written, thus increasing its reading difficulty. This will be discussed no further.

However, the two remaining facets that are a matter of importance are for the purposes of this report referred to as "vocabulary load" and "Gestalt."

The factor of vocabulary load deals with the terms that are used throughout the book. These terms may be placed into two categories, (a) technical, (b) non-technical. The terms in the technical category are those which are unique to a particular field of science and an understanding of which is essential for an understanding of the course. In the field of biology such a term might be "organism"; in chemistry, "atom"; in physics, "force"; and in earth science "diastropism." There are no specific facts available as to what constitutes a technical vocabulary that is too large. However, it is likely that a vocabulary load of more than 200 "essential," and 200 "desirable," terms is somewhat excessive.

Further, unless those terms are chosen by means of research techniques that indicate their essentiality and desirability, then the number of terms used becomes meaningless. Thus in terms of vocabulary

load the factor to be considered is the size of the vocabulary as developed by research techniques not assembled from opinion.

The non-technical vocabulary consists of those terms that the student is likely to use in his everyday speech and that are not unique to the subject-matter field. With few exceptions it is inexcusable to find in the textbook many difficult non-technical terms since most of them can be replaced with easier synonyms. Where difficult non-technical terms are used they are best spelled phonetically and defined in footnotes.

In general the grade-level of difficulty of the non-technical words should not be higher than one grade level below that of the grade for which the book is designed.

However, if the book is too difficult for the students it is obvious that measures must be taken to enable the students to use it as effectively as possible. The teacher should first identify the words, sentences and passages that are liikely to cause difficulty. The words that seem likely to be a source of difficulty should be checked against one of the standard word lists.[5,6] A list of those words that are found to be difficult may well be prepared and placed in the hands of the students. Of course, this is not a suggestion that the students be expected to memorize the list of words together with the definitions. Rather the list should be used for ready reference. Thus the student is not likely to have his trend of thought interrupted by lengthy excursions to the dictionary, or to develop misconceptions because of the failure to understand the words that he reads.

The term "Gestalt" refers here to the general patterning of the ideas that the writer is attempting to express. In many cases the ideas are expressed with a fair degree of clarity, but the sentences are composed of many ideas rather than one or two. Hence the level of comprehension may be quite high even though the individual words in and of themselves may not be difficult.

To use effectively a textbook that is difficult with respect to reading level may involve an occasional "old-fashioned" reading period in which a pupil may read aloud a section from the book and the group may then discuss it. This technique of course should be used judiciously and only when the students are not likely to profit from the individual reading of certain passages.

An ingenious teacher will of course find many techniques that may be suitable beside the ones mentioned here. It is important however that the teacher analyze the book to locate difficult passages and then make efforts to minimize the difficulties that the pupils are likely to have with them.

III. *Use the Illustrations.* Without doubt illustrations have tre-

[5] Buckingham, B. R. and Dolch, E. W., *A Combined Word List.* Boston: Ginn and Co., 1936. Pp. 185.
[6] Rinsland, Henry B., *A Basic Vocabulary.* New York: The Macmillan Co., 1945. Pp. 636.

mendous eye appeal. Further, the addition of color increases their attractiveness. However, these factors are not alone, or at least should not be, the reasons for the presence of illustrations. The cost of illustrations would be unjustified if this were the only reason since illustrations are expensive. A number of high-salaried artists must be employed, each of whom is adept in producing a specific type of diagram. Some produce the line diagrams, others the biological diagrams, others the figures and faces of human beings, and others the caricature-type of illustrations. A single photograph may cost more than twenty dollars. A single color insert may increase the cost of a book as much as eight cents. Obviously then where illustrations and color can be eliminated, savings will be made.

What then is the value of the illustration?

Open any of the more popular textbooks to a half- or full-page illustration. Examine the illustration carefully. Then try to reproduce in words the principles, facts and knowledges in science that are evidenced in the illustration. Without doubt it would require two or more pages to do so. Thus it is obvious that illustrations are used since they present ideas more effectively, and in less space, than do words. Further a perceptual pattern is established in the mind of the student with less error than is likely with the interpretation of the verbal symbol.

Occasionally one hears the comment that a book contains too few illustrations or is too profusely illustrated. The results of a "page-inch analysis" of over one hundred textbooks of science provides evidence that, except for a few of the less popular books, the comment is invalid. In all the popular textbooks of science the space devoted to illustrations ranges between thirty-six per cent to forty-two per cent of the total space. The median amount of space devoted to illustrations is about thirty-nine and one-half per cent.

If any criticisms are to be directed at illustrations they will involve chiefly the placement, the quality and clarity of reproduction, the effectiveness of the particular type of illustration, the extent to which the illustration is related to the topics in question, and the extent to which the legend requires the student to think critically or to which it extends his understanding beyond that provided by the printed page.

The points mentioned here may serve well as bases for questions and exercises in which the student attempts to evaluate the illustrations and to gain further knowledge by relating the illustrations to the topics in the textual material. Further the students may be given opportunity to make simple diagrams that can be substituted for those in the textbook. All these activities will exploit the purposes for which illustrations are designed.

IV. *The Activities at the Ends of Chapters.* An analysis of the ac-

tivities found at the ends of the chapters indicates that a great number of authors toss them in as excess baggage. This seems to be true even with some of the more popular textbooks. However, in a well-planned textbook the end-of-chapter activities serve a very useful function and should be used with maximal effectiveness.

As has been indicated earlier the textbook should be written for a level of difficulty (reading) of about one grade below that of the students for whom it is designed. Thus the textual material may not be completely suitable for the inferior or superior student. The end-of-chapter activities should be designed partly to provide for these individual differences, especially in the case of the superior student.

In the better textbooks activities may contain discussions of more advanced materials suitable for these students, they may suggest experiments and projects that the better students may prepare and demonstrate before the class, and they may contain questions that will enable students to apply and extend their knowledges of science more widely in their environments. Obviously, no specific statements can be made since the activities vary widely from book to book. It is important, however, that the teacher examine the activities to find out what uses may be made of them. Many of them of course will not be used.

In summary, the problem seems to emphasize the necessity of making effective use of the textbook rather than "shall we use one." Probably any teacher, spending a small amount of time judiciously, can make effective use of what the textbook offers. In addition such time may save many hours in searching for materials that the textbook already provides, but of which the teacher is unaware.

You have the textbook. Use it! Don't let it use you!

FOX HONORED BY NEW JERSEY TEACHERS

H. Harbert Fox, senior chemist with Hoffman-LaRoche, Inc., has been selected to receive the Scroll of the New Jersey Science Teachers Association as the New Jersey resident who has contributed most to science during the past year. The award is being given to Dr. Fox for his work on the chemotherapy of tuberculosis and his discovery of the anti-tubercular hydrazide.

The Scroll will be presented to Dr. Fox at the association's dinner meeting at Atlantic City on November 13th. Steuart Faber president of the N.J. Science Teachers Association will make the award.

Electric sander fits snugly into the palm of the hand and works on ordinary house current. A polishing pad can be substituted for the sanding pad to help the housewife make her furniture shine and her metalware glisten.

MATHEMATICS AND ITS ENGLISH

ROBERT E. FLEMING
Southern Okanagan High School, Oliver, B. C., Canada

A high school student's ability in Mathematics is dependent to a great degree upon his knowledge and proper use of English fundamentals.

One of the chief English requirements for success in studying Mathematics is an ability to read and to summarize—an ability to pick out of the statement of a problem the essential information given and the specific question or questions to be answered. This is true in simple arithmetic and algebra problems. The student, by reading a problem once, twice, or even three or four times, must be able to picture the problem and to separate the facts given from the facts required. From a geometric proposition he must be able to pick out the data and the aim.

All this requires not only reading ability but also good reading comprehension. And it requires careful reading, because one word or phrase misread or unnoticed can make a great deal of difference in arriving at satisfactory answers. Neglect of such words as "in feet" or "not" may be costly.

After this initial stage of solution is completed, the student must perform an equally important task. He must write out his solution or proof in logical steps and in lucid English. In other words he is writing a mathematical composition, and as in an English composition his sentences must follow a logical pattern. Everything he writes must lead to a climax—the solution to the problem.

Moreover, in Mathematics a student's written statements must be short and concise. He must give all the necessary facts in as few words as possible. There is no room for descriptive adjectives and adverbs in the solution of mathematical problems. Then in place of the statement

"Cost of 500 linear feet of pine picture molding at $3¢ = 500 \times 3¢ = \$15.00$" he could write

"Cost of molding—$500 \times 3¢ = \$15.00$"

This latter statement is brief; it tells what is being found, how it is being found, and it states the answer.

An understanding of the fundamentals of English grammar is also essential to success in mathematics. For example, the equal sign must be treated as a copula verb, and if the student knows what a copula verb is he will know that whatever he places to the right of the equal sign must represent the same thing as what he places to the left of it. Thus weight cannot equal volume, and the statement $x/2 = \frac{3}{4} = 4x = 6$

is incorrect. Again, the definition "Congruency is *when they* are equal in all respects" is hardly acceptable grammatically.

Even good spelling habits are desirable. By the time a student reaches high school he ought to have learned to spell correctly in all subjects, rather than putting forth a real effort in English classes and forgetting that spelling habits should carry over into all fields of his endeavor, scholastic and otherwise. If he comes upon a new word in his mathematics class, such as the word "theorem," his previous training should make it almost second nature for him to realize that it *is* a new word, that in all probability he will be required to use the word frequently in future, and that he may just as well learn to spell it now as later.

It should also become automatic for a student to look up the meanings of words he doesn't understand. This is probably part of the training required for improving reading comprehension. The dictionary has as important a place in the mathematics class as it has in any other class, because frequently one is required to find the frustum of a cone or to know the difference between the terms "power" and "exponent." The English language has many words which differ only slightly in their meaning, and if a student has become aware of this fact, he will not find it too hard to realize that rectangles, squares, parallelograms and rhombuses are not necessarily the same figures even though they are all quadrilaterals. And here a student must exercise great care in his definition of terms. His wording must be such, in defining a square, that he defines all squares and nothing that is not a square. Part of a mathematician's stock-in-trade must be a mathematical vocabulary with which he is thoroughly familiar. He must be able to spell, pronounce, define and use correctly whatever mathematical term he encounters.

Hence a good understanding of the rules of English grammar and composition and a high level of reading and spelling ability are basic requirements for a good mathematics student.

It must be noted as well that a number of high school students will eventually become accountants, engineers or statisticians. In these and similar fields, where one's writings in mathematics are to be read by others, the use of good English becomes doubly important. The spelling, grammar and composition of such reports must be of a high caliber. The reader will be more likely to understand what he is reading, and the writer's works will be more acceptable from the point of view of accuracy simply because it is written in good English.

Electronic "eye" for automobiles automatically dims your headlights when on-coming traffic is encountered. Now being readied for full-scale distribution as an auto accessory, the device draws little battery current and comes complete with an install-it-yourself booklet.

INSTRUCTIONAL MATERIALS FOR SHOWING APPLICATIONS OF SCIENCE

SAM S. BLANC
East High School, Denver, Colorado

The area of scientific applications is so wide that it is most difficult to suggest materials for instruction. To stimulate the thinking and interest of pupils in this area, a number of motion pictures and filmstrips are available. These should be thought of more as reference points around which the units of study relating to this topic might be built up. The details of integrating other instructional materials must be left up to the individual teacher in this case since the approach will vary with the needs of each particular class.

Hydro-electric power is discussed in two one-reel motion pictures, *Water Power* (EBF), and *Energy in Rivers* (COR). Two filmstrips dealing with this topic are, *Power of Clouds* (EGH), fifty frames, and *Harnessing the Rivers* (ACE), thirty-nine frames. Additional titles which might contribute an understanding to this topic are as follows:

1. *Bright Path*	3 reels	b & w,	IFB
2. *Colorado River*	1 reel,	b & w, color,	COR
3. *Power from Shipshaw*	1 reel,	b & w,	CNF
4. *Romance of a River*	2 reels,	color,	IFB

Scientific developments helping in earning a living could be dealt with in a number of ways. Individual excursions may be planned by pupils to visit enterprises in which various developments illustrate scientific applications. Charts, posters, and other pictorial materials are available from many commercial sources. Several motion pictures which are excellent examples of this area are:

1. *Chemistry and a Changing World*	1 reel,	b & w,	EBF
2. *Drama of Steel*	3 reels,	b & w,	USM
3. *Machine Maker*	1 reel	b & w,	EBF
4. *New Ways to do more with Farm Power*	2½ reels,	color,	SOI
5. *Science and Agriculture*	1 reel,	b & w,	EBF
6. *Unfinished Rainbows*	3 reels,	color,	MTP
7. *What are Machines*	1 reel,	b & w,	BF

A third division in this area could be the general contributions of science to an improved standard of living. A new filmstrip, *Making Atomic Energy Help Mankind* (PSP), forty-five frames in color, might be used. This topic has an almost unlimited number of sponsored motion pictures available. Many of the sources of free and inexpensive materials available to the teacher will have motion pictures for school use. The teacher must realize that sponsored materials are produced as one method of advertising the company and its products. Hence, some advertising material is to be expected in

these productions. As a general rule, the amount of advertising present in sponsored motion pictures and filmstrips is well within reason. However, the teacher will usually find that previewing the films before using them in class will be a wise precaution. After seeing the entire presentation, a decision as to whether the material is suitable for class use may be made. As a small sampling of the many motion pictures available in this area, the following list of titles is given:

1. *Curiosity Shop*	3 reels,	color,	MTP
2. *Dawn of Better Living*	1½ reels,	color,	WES
3. *Gasoline's Amazing Molecules*	2½ reels,	color,	SOI
4. *The Growth Industry*	3½ reels,	color,	MTP
5. *Horizons Unlimited*	1½ reels,	b & w	NHU
6. *On the Air*	2 reels,	b & w,	WES
7. *On to Jupiter*	2 reels,	b & w,	GM
8. *Petroleum and Its Uses*	4 reels,	b & w,	USM
9. *Rainbow Harvest*	2½ reels,	color,	MTP
10. *Research: Pattern for Progress*	2 reels,	color,	MTP
11. *Rubber Goes Synthetic*	2 reels,	b & w,	ESO
12. *Styling the Motor Car*	2 reels,	color,	GM
13. *Story of Lubricating Oil*	2½ reels,	b & w,	SOI
14. *Time: the Servant of Man*	2 reels,	b & w,	MTP
15. *Years of Progress*	3 reels,	b & w,	MTP

SOURCES OF MOTION PICTURES AND FILMSTRIPS

ACE	American Council on Education, 744 Jackson Place, Washington, D. C.
BF	Bailey Films, 6509 DeLongpre Ave., Hollywood, Calif.
COR	Coronet Films, 65 East South Water St., Chicago, Ill.
CNF	National Film Board of Canada, 1270 Avenue of the Americas, New York, N. Y.
EBF	Encyclopaedia Britannica Films, 1150 Wilmette Ave., Wilmette, Ill.
EGH	Eye Gate House, 330 W. 42nd St., New York, N. Y.
ESO	Esso Standard Oil Co., 15 W. 51st St., New York, N. Y.
GM	General Motors Corp., Film Distribution Section, 3044 W. Grand Blvd., Detroit, Mich.
IFB	International Film Bureau, 6 N. Michigan Ave., Chicago, Ill.
MTP	Modern Talking Picture Service, 45 Rockefeller Plaza, New York, N. Y.
NHU	National Highway Users Conference, 938 National Press Bldg., Washington, D. C.
PSP	Popular Science Publishing Co., A-V Division, 353 Fourth Ave., New York, N. Y.
SOI	Standard Oil Company of Indiana, 910 S. Michigan Ave., Chicago, Ill.
USM	U. S. Bureau of Mines, Graphic Services Section, 4800 Forbes St., Pittsburgh, Pa.
WES	Westinghouse Electric Corp., School Service Dept., 306 Fourth Ave., Pittsburgh, Pa.

ANTI-FIRE PAINT

Anti-fire paint helps stop blazes from spreading by exuding carbon dioxide and calcium chloride when fire licks surfaces coated with it. These chemicals produce a smothering action by choking off the fire's oxygen supply. The fire-retardant interior oil paint is said to be suitable for industrial use and may find applications aboard ships.

SOME OPPORTUNITIES IN CHEMISTRY FOR PROBLEM-SOLVING*

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There has been increased emphasis in recent years on problem-solving as one of the goals or objectives of modern secondary education. This emphasis has been particularly significant for chemistry, since by its very nature, chemistry offers rich potentialities for problem-solving experiences for students. Chemistry teachers are making use of many of these potentialities, but many feel that they need to explore additional possibilities.

Problem-solving might be said to involve the use of reasonable and orderly procedures to determine the answer to a question for which no proven answer is readily available to the individual. There seems to be no one inflexible procedure or rigid set of steps which must be followed in finding the solution to all problems, regardless of the situations in which they arise or their degree of complexity. However, there are some problem-solving abilities which may be identified, such as: recognizing a problem; analyzing a problem to determine significant factors; differentiating between facts and assumptions; making hypotheses; subjecting hypotheses to tests; observing accurately; and drawing conclusions.[1]

The development of abilities such as these is not necessarily achieved automatically through taking a chemistry or other science course. The student learns problem-solving best through engaging in actual problem-solving experiences and participating in activities which develop problem-solving abilities. Chemistry teaching can provide ample opportunities for such experiences and activities. A few of these are discussed in following paragraphs.

Increased emphasis on real problem-solving experiences may be secured through modification of a portion of the usual laboratory work. One of the possible modifications that can be made is for the teacher to introduce a new topic for study by raising pertinent challenging questions regarding the topic or by stimulating and leading students to raise such questions. Some of these questions may pose a real problem to the students—a problem which they genuinely desire to solve. If so, the students and the teacher working together can explore possibilities for using the laboratory to find answers or partial

* Presented to the Chemistry Section of the Central Association of Science and Mathematics Teachers at the Edgewater Beach Hotel, Chicago, November 28, 1952.

[1] For more extensive listings of problem-solving abilities, see *Science Education in American Schools*, Forty-Sixth Yearbook of the National Society for the Study of Education, Part I, Chicago, University of Chicago Press, 1947, p. 29, and Progressive Education Association, *Science in General Education*, New York, Appleton-Century-Crofts, Inc., 1938, p. 311–313.

answers to the problem, and can develop together procedures to be used in the laboratory. It may be very likely that several laboratory operations or experiments designed to aid in solving the problem will be developed so that students will not necessarily be duplicating the work of their neighbors. The teacher can work with the students as they propose and develop plans for laboratory work and can have ample opportunity to guide the development and to rule out various proposals on the basis of danger, inaccessibility of materials, inordinate consumption of time, or other pertinent reasons. When plans have been developed and are approved by the teacher, the students can proceed to carry out in the laboratory the work which they have helped design and which may result in shedding light on a problem they wish to solve. A further step might be for students and teacher to develop conclusions as indicated by the shared outcomes of the laboratory work and to proceed to enlarge their understandings and verify their conclusions by the study of textbooks and supplementary materials and the use of other usual classroom procedures. Such use of the laboratory is more time-consuming and more difficult to carry out than some more conventional uses, but it does seem to offer one fruitful way for students to find answers, to exercise some of the elements of problem-solving, and to grow in problem-solving skills.

Opportunities may be provided for students to solve problems of their own choice in the chemistry laboratory. Students may choose from a variety of possible problems. Some may recognize problems in their own immediate environment which they wish to solve. These problems may arise from observations made in or about the home, from reading newspapers and magazines, or from any of the wide variety of experiences that young people have. An example of such a problem is provided by the student who comes to his chemistry teacher and relates the following: "The copper connection on the battery cable of our car came loose yesterday. We found that it was covered with some bluish material and was completely eaten through in one place. What did that—the fumes from the battery, the heat from the motor, the electric current passing through it, a leak in the battery allowing acid to get on it, or what?" Instead of telling the student the probable answer to his problem, the teacher can encourage him to use the laboratory in seeking his own answer. He has already recognized a problem and has made some hypotheses. He can now devise experiments to test these hypotheses and can check his conclusions by consulting various sources of authentic information. Obviously, considerable guidance on the part of the teacher may be needed with some problems. Some students may be challenged by practical problems suggested by the teacher. It is essential that students have a genuine interest in using the laboratory to find the

answer to the problem they choose. The teacher can develop a file of such practical problems having their origin in familiar situations or taken from common everyday sources. An example of such a problem is suggested by a bulletin appearing recently in a newspaper[2] stating that over 600 convicts in a state penitentiary had become ill from food poisoning believed caused by new zinc cooking utensils. The teacher might make a copy of this newspaper bulletin or clip it from the newspaper and mount it in a fashion suitable for filing. Questions, instructions, and suggestions for students using the problem might be noted with it before filing, such as:

Is the belief stated in this bulletin a real possibility?
What experiments can you devise that will help you find the answer?
How will you verify your conclusions?
Keep a written record of just what you think and do and the results you get as you go about finding an answer.
(Have your plans for experiments checked by the teacher before using the laboratory.)

Demonstrations, which are used for achieving a variety of objectives in chemistry, may also be used in the development of problem-solving abilities.[3] Demonstrations used appropriately for this purpose need not be complex. Neither do they need to be essentially different from demonstrations used for other purposes. However, the objective sought may affect the placing of various emphases and the manner of performing the demonstration. In a given demonstration emphasizing the development of problem-solving abilities, the teacher may be concerned with such factors as the following:

Are students able to observe accurately what happens in this demonstration?
Can students differentiate between assumptions and demonstrated facts?
Do students recognize the function of the control?
Can students draw conclusions consistent with the data provided by the demonstration?

Appropriate guide sheets or question sheets prepared for students' use with the demonstration may serve to emphasize and point up the use of problem-solving abilities.

The opportunities in chemistry for problem-solving discussed briefly here are merely indicative of the variety of such opportunities available to the chemistry teacher who actively seeks them.

[2] *The Columbus Dispatch*. Columbus, Ohio. The Dispatch Printing Co. Vol. 82, No. 148. Tuesday, November 25, 1952, p. 1.

[3] For a discussion of this use of demonstrations see G. P. Cahoon, "Using Demonstrations for Providing Pupil Experiences in Thinking," *Science Education*, Vol. 30, No. 4 (October, 1946), pp. 196–201.

Imitation marble, for beautifying and renovating furniture and wall surfaces, resists heat, stains, weather and rot and does not break as easily as marble. Made of the same polyester material now being used in the manufacture of plastic boats, the "marble" is applied in a simple, quick adhesive process.

A REPORT ON AN EXPERIMENT WITH THE EXPERIMENTAL METHOD

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Learning by doing is an old educational adage, and science education seems to be a made-to-order subject in which this adage can be put to work; and, if in the doing, scientific thinking can be taught, then, when students are provided with the materials and apparatus with which they can solve problems and learn scientific thinking, it does seem that the extra planning, effort, and care are worth while.

The point of this report is not so much a comparison between a strictly-teacher-demonstration-method and a method in which the individual students themselves work with materials and apparatus, but rather a description of one way of making student experiments possible, and an attempt to evaluate the results.

This experiment took place at the Jefferson Intermediate School, beginning in September, 1950, and extending to June, 1952. The text used was "Science Problems," published by the Scott-Foresman Company. The grades involved were Grades 7, 8, and 9, but for the purpose of this report Grade 7 will be considered only, as the subject matter seemed to lend itself better for experimentation, although the experimental method was also used in the other grades where it seemed practicable. The subject matter dealt with the topics of: "What is a material?" "How can one material be changed into another?" "How do heating and cooling change materials?" and "How do we use and control fire?"

The science room is equipped for experimentation. There are eight gas and water outlets in a counter along the window side and the back of the room. Under the counter are drawers and cupboards in which was stored the basic apparatus. This includes a bunsen burner, a ring stand, a screen with asbestos center, a 25 mm. and a 50 mm. beaker, funnel, and a test tube brush. The drawers and cupboards were numbered and assigned to various groups, as will be explained later.

The classes were divided into two groups, designated as Group I and Group II. Both groups were divided into smaller units of two or three students, making eight smaller units within each larger group. In this way a class of 32–48 in number could be managed. The members of the smaller units chose their working partners and were assigned to working spaces. We called them stations, 1–8. At the outset the class was also cautioned about the improper use of materials as well as the dangers of using gas, fire, and glass. The specific dangers were also pointed out at the beginning of any experiment where such dangers existed. Fortunately it can be reported that the students

were extremely careful, and that only a very few forgot about touching hot test tubes or the like. Breakage of glass was also kept at a minimum, the students realizing that our supply was quite limited.

We also had what we called a supply table at the front of the room. On this table were wire baskets for each experiment. Each basket was labeled, and in each basket were the materials necessary for that particular experiment. These materials might include test tubes, various elements or compounds, filter paper, rubber tubing, rubber stoppers, and the like. Before the students started their experiments, they were given instructions about the materials which would be necessary to use.

The working procedure was carried out in this manner:

At the beginning of the week, the class would receive an assignment written on the blackboard and left there for the rest of the week for ready reference, as, for example:

7A's—Unit Three—Problem Two.

1. Read pages 124–136
2. Prepare Experiments 5, 6, and 7. (Described in the textbooks)
3. Write answers to the Self Testing Exercises, pp. 126, 130, 136.
4. Prepare Problems to Solve for oral discussion, page 136.

The above adaptation from the suggested methods of the authors of the text was designed to fit a curriculum in which a science class meets four times per week. These four assignments would be carried out by the two groups by having one group experiment while the other group read, wrote, and prepared problems, as indicated in 1, 3, and 4 above.

An attempt was made to compare the results of this method with the strictly teacher demonstration method. However, it was found that too many variables were present, chief among which was the teacher element. Even though an effort was made to set up matched classes which met in different science classes, it was still found that these classes, too, differed in previous experiences and abilities. However, by teacher observation during the experimental periods, and by direct questioning of pupils relative to the advantages of the experimental method, it seems reasonable to draw the following conclusions:

1. Students enjoyed the atmosphere of a busy workshop.
2. Students enjoyed being released from their desks during their group's experimental period.
3. Students enjoyed "making like a scientist."
4. Students enjoyed using the various kinds of apparatus and materials.
5. Some students, not all, gave evidence of good scientific thinking.
6. All the students agreed that this method was more difficult because they had to think for themselves and had to plan their work more.
7. This method is more difficult for the teacher because in the atmosphere of a busy workshop a few students are likely to take advantage of the freedom permitted.

8. This method also requires more time in which to provide the class with the materials and apparatus needed for the experiments.

However, the best evaluation, to me, and that which gave me the greatest amount of satisfaction, was the many eager faces of the students who almost daily asked me as they came to class, "Are we going to experiment today?"

DR. GREENLEE GOES TO FLORIDA STATE COLLEGE

Dr. Julian Greenlee, Professor of Physics at Western Michigan College of Education, has accepted an appointment as Professor of Education at Florida State College, Tallahassee, Florida. He went to the Michigan College as critic teacher in the training school in 1940. He has a Bachelors Degree from Southern Illinois University, Masters Degrees from the University of Illinois and Teachers College, Columbia University and a Doctors Degree from the latter institution.

Dr. Greenlee has taught in one room rural schools, high schools, colleges and universities. He served during the past summer as visiting Professor of Science Education at the University of Maine. He is an active member of professional organizations including The Association for Childhood Education, The Association for Supervision and Curriculum Development, The Central Association of Science and Mathematics Teachers, The National Association for Research in Science Teaching, The Michigan Education Association, The National Education Association, and The National Council for Elementary Science. He is a past president of the latter organization.

THE COMMISSIONER OF EDUCATION SAYS

School Construction—

School construction in the United States is not keeping pace with classroom needs. Increased enrollments, building deterioration and obsolescence will create the need for an additional 425,000 classrooms and related facilities by 1960. About 36,000 are in some stage of construction at this time.

Capital Investment—

The total national capital investment in elementary and secondary school plants is estimated at 16 billion dollars for public schools, and more than 1½ billion dollars for private schools. The Nation's capital investment in college and university plants is estimated at 6½ billion dollars.

Teachers—

The number of persons being prepared as teachers is inadequate to meet teacher needs in the United States. Some 45,700 qualified graduates for the elementary field came out of the colleges this year. Since there is a need for 118,000 public elementary school teachers, the net shortage of qualified elementary school teachers is about 72,000. This shortage can be overcome only by further overcrowding, or by recruiting into the elementary schools teachers whose qualifications fall short of desirable standards.

Transportation—

More than 8,000,000 public elementary and secondary school pupils go to school daily by bus. Their 115,000 buses, 15,000 stations wagons, and other types of transportation form the largest fleet of passenger-carrying vehicles in the world. The public expenditure for this service during 1953–54 will be more than a quarter billion dollars.

THE FUTURE OF MATHEMATICS EDUCATION IN THE SECONDARY SCHOOL

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I. TRADITIONAL ATTACKS ON MATHEMATICS

From the time when it occupied a place of prestige in the curriculum of our fathers and even in our younger days, mathematics has been subjected to attacks. It has even been dropped as a required study from the schools in many states of the Union. It is not strange that this should have happened, because many teachers, in spite of suggestions for a modern course of study, persisted in teaching the more formal and less useful parts of the subject.

Mathematicians as well as others have criticized mathematics. Men like Sylvester, De Morgan, Hamilton, and Perry[1] are examples of the kinds of critics we have had among the mathematicians.

Many people who have attacked the subject may not have been capable of offering constructive criticism, but they at least knew that the study of mathematics was not paying dividends commensurate with the amount of time and energy spent on its organization and teaching. No one group of teachers has had a monopoly on stupid teaching. It can be found in every field. However, this fact does not minimize our obligations, or relieve us of the responsibility of improving the content and the methods of teaching mathematics.

When a group of mathematics teachers was recently reminded of the numerous attacks on the teaching of the subject, one teacher replied, "We should worry, we are no worse off than the teacher of English!" Perhaps not. The teaching of English, like that of mathematics and the other subjects, has frequently been bad enough. However, such an attitude should not be consoling to forward-looking teachers.

The blame for the present situation in mathematics should not be placed upon the teachers of the subject, although they may have some responsibility. The fault lies with our entire educational philosophy or lack of it, and the way our educational system is administered. Does anyone think that the teaching of mathematics is any worse than the teaching of other subjects? For example, are poets, novelists, and the like being turned out in larger numbers today than formerly by the English teachers? Are the Plutarchs, the Gibbons, the Bancrofts, and the Beards being trained in larger numbers by the teach-

[1] Discussion on The Teaching of Mathematics, Edited by John Perry, Macmillan and Company, London, 1902. See also Reeve, W. D. "Attacks on Mathematics and How to Meet Them," Eleventh Yearbook, National Council of Teachers of Mathematics, *Mathematics in Modern Education*, Bureau of Publications, Teachers College, Columbia University, New York, 1936, p. 1–21.

ers of history, or are these teachers really producing by their instruction a higher type of citizen? Recent reports on the results in the social studies are alarming! And so we might go on through all the great fields of knowledge. No, the answer is that the trouble lies deeper. By and large, the teachers are doing about as well as can be expected under the circumstances, but clearly the best is none too good!

Some people, when they criticize mathematics or raise questions as to its value, are thinking of the more advanced stages of the subject with which they are not familiar or perhaps with which they may have had an unfortunate experience some time in their lives. They may even have failed the subject.

Algebra and geometry particularly, are coming in for an appreciable share of criticism. Everybody from the general educationist to the man on the street feels himself competent to criticize. In several plays in New York City, one of the characters in each play takes great satisfaction in criticizing mathematics. One character remarked, "Why, she is as crazy as my geometry teacher," implying of course more than probably was intended. The interesting thing about each incident is that when these attacks were made the audience reacted with a chuckle of approval.

While most of the criticisms of mathematics are hurled at a type of mathematics teaching that has been outmoded in many schools, there is still just cause for complaint. Why is it that so many people who have studied algebra or geometry have such an antipathy for the subject? What is the real reason? The critics have said that tradition alone is not a sufficient reason for giving mathematics the prominent position it holds in the school curriculum. Moreover, they have said that even when properly taught, mathematics may have values of extreme importance, we should not continue to give so much time to its study unless we can show that it functions properly in the student's life. The nature of some of the complaints are as follows:

1. The teaching of mathematics does not result in correct practices among the students who study it. The trouble is that children who have studied arithmetic through the eighth grade are not able to pass satisfactory tests on some of the simplest elements at the end of the senior high school.

Recently I overheard two prominent educators discussing the shortcomings of some of the current school practice. One of them said, "Now take mathematics, for example, the trouble is that it never gets back into life; even the arithmetic or the other subjects that we teach in the junior high school." Can we deny that on the whole the statement is true?

There is no need of discussing further now the values to be obtained from the study of mathematics, for on most of them, at least, people generally are agreed, but the greatest objection to be met is that we are not securing these values. For one thing, the conventional first-year algebra course has been characterized by excessive formalism that cannot be justified.

2. Too many students fail in algebra and they spend too much time in failing. Much of this difficulty might be avoided if we began the study of algebra earlier as the Europeans do and spread it out over a longer period of time. Moreover, if we would concentrate on those things in algebra which the well educated citizen needs to know and then strive for a desirable percentage of mastery, the results thus obtained would be far superior to present day conditions. In a study of failures in various high-school subjects in New York City there were twice as many failures in mathematics in the schools studied as in any other subject, the nearest competitor being foreign languages, Latin particularly, with a little less than one half as large a percentage of failures.

Although the one making this report failed to call attention to the fact that algebra is required by all and is taken in the ninth grade, while some of the other subjects like physics and history were taken later, one is not justified in thinking that, in the long run, such large percentage of failure can be productive of good.

On the other hand, a realization that some parts of our mathematics courses are not so important as others and that some other parts are entirely too difficult or impractical has led us to initiate movements to ameliorate the situation. The algebra textbooks of today are not so difficult as they were a few years ago. The geometries have also come in for their share of curtailment of difficult topics such as the theory of limits and incommensurables. In general, all of our mathematical requirements for graduation from high school and for admission to college have been made easier.

In spite of all this, however, the cry for further reform has gone on. Once the critics have succeeded in getting formal algebra reduced, they begin to question its position in the curriculum. Once the difficult parts of demonstrative geometry have been eliminated, a movement is started to reorganize the entire field and to postpone the teaching of it.

The question then is, How may a proper selection of material be made and a just division of time be allotted so that school officials may feel justified in requiring a student to spend some time studying mathematics?

3. Too many students hate algebra even though they may not fail in it. Maxine Davis said:

"Experiments show that many children who are compelled to study algebra get little or no value from it. On the contrary, it arouses irritation and annoyance, and a desire to escape school. How often have we heard our parents say 'Your school days are the happiest days of your life!'

"Well, mine weren't. There was that eternal bugaboo of geometry and trigonometry."[2]

How can we expect people who have had such experiences with mathematics to be anything but critical? Someone may say such people are exceptions, but I do not believe that is true.

4. The many difficulties of Euclidean geometry have been crowded into one year's study for the student and the inevitable result is a kind of memoriter learning that is a disgrace to all concerned. The remedy here, as in algebra, is to simplify material, center on the important ideas, and spread the instruction out over a longer period of time. Such a procedure gives the student the vocabulary, the symbolism and the fundamental ideas of the subject.

Heywood Broun, late columnist for the *New York World Telegram* once said, "There must be something wrong with the manner in which we teach the young idea how to shoot when such a large number of pupils hate their studies with so palpable a passion." He then went on to say, "I have a vague impression that some of the higher mathematicians have announced that the axiom is no longer true. Einstein and others have brought curves back into favor. And all this irritates me no end because, whether it is true or false, my difficulties in acquiring the hypothesis have borne no later dividends. I cannot think of a single tough spot in my existence in which Euclid reached down to lend a helping hand." Just so! And how many other boys studying geometry today will give the same kind of testimony? What is the cause of such antipathy toward mathematics? I think it is largely due to the stupid way in which mathematics is too often presented to the students.

5. The doctrine of transfer has been seriously questioned. While no one today would wish to defend the traditional view of over zealous mathematicians one could hardly subscribe to the claims of some educational psychologists. The fact is that transfer does take place, but if the teacher wishes transfer to be real, he must decide first what transfer he wants and then see that the possibilities for such transfer are made as advantageous as possible.

This brings up another important tendency, namely, to require teachers of mathematics not only to know something about psychology, philosophy and the like, but also to know something about the subject which they expect to teach.

Such attitudes as those expressed above are not exceptions. They

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[2] Davis, Maxine, "The Little Red School House," *McCall's* Magazine, February, 1934.

appear constantly all over the country. At a recent dinner I sat next to a seemingly refined woman who, when I told her I was a mathematics teacher, said, "How in the world can you ever make that subject interesting to children?" I replied that the task was very simple, but I do not think that she believed me.

The above criticisms and many others make me realize that one of the most important problems for us to consider at the present time is the very existence of mathematics in the curriculum of the secondary school. Some teachers of mathematics who have heard such attacks are inclined to take a less serious attitude toward the question. They, like some of the students, say "if anything is to be dropped let it be the fads and the frills."

Again, we cannot dismiss attacks like the above by ridiculing the critics. They may be, and often are, ignorant of mathematics, and in some cases they may have been the victims of non-mathematically-minded teachers, but they are not stupid. They know that the teaching of mathematics is not what it should be, and they are determined to bring about improvement if not absolutely to drive mathematics from the curriculum.

We are all aware that the students in the secondary school are not equally gifted in the study of mathematics. Some of them should certainly be excused from further study of it, but no one, I think has wisdom enough to decide who will profit most by its study or who the future Newtons and Einsteins are to be. David Eugene Smith's delightful stories of the unpromising youths who later became prominent mathematicians point the proper moral here.

The worst part about all of the traditional attacks on mathematics is that even the friends of the subject have been more or less apathetic about these attacks and have done little to offset them. The criticism can be met in two ways. First, by admitting our shortcomings where they are true and, second, by going on the offensive. Some of us have raised our voices, but for the most part we were either not heard or the people, whom such voices tried to reach, heard, but did not care.

II. The Recent Situations in Mathematics

Just prior to Pearl Harbor mathematics was perilously close to being in the educational "doghouse." Many influences were working either to curtail requirements in the subject or to throw it out altogether. Enemies of mathematics were even willing to dispense with most of the operations in arithmetic except the most elementary. Some of them worked out in the open, others were more subtle and chose to get arithmetic out of the schools by asserting that the arithmetic of a certain year was too hard and therefore it should be

taught in a later year. This process was called "stepping up" arithmetic. The same argument was used to get geometry postponed until the eleventh or twelfth year and similarly for algebra and trigonometry. Solid geometry had already disappeared from most courses of study, and, in fact, was not any longer required for entrance to many leading engineering schools in this country. This doctrine of postponement did a great deal not only to "step up" subjects but ultimately to "step out" some of them.

The Awakening Concerning the Value of Mathematics. I pointed out in an editorial in *The Mathematics Teacher* for October, 1940, before we entered World War II, that:

"The nation's wide interest in the new defense program has brought mathematics into the foreground once more. Young men who are anxious to get into certain lines of defense work have discovered that without adequate training in secondary school mathematics their future in defense work is likely to be handicapped if not entirely thwarted. This fact has been known all along, but too many school men and women have been led away from the real value of mathematical education by the songs of the sirens who have been singing about the 'Child Centered School,' 'Incidental Learning' and the like. Now is the time for mathematics teachers everywhere to meet the challenge afforded by the defense program and show that not only in preparation for war, but in peace time as well the success of many individuals in many lines of endeavor is dependent in a large way upon the training in mathematics that the individual concerned has received."

The same situation still exists for a great many of our youth at the present time.

The annual meeting of The National Council of Teachers of Mathematics at Atlantic City in February 1941 dealt entirely with the defense program. *The Mathematics Teacher*, for May, 1941 was devoted to the place of mathematics in the defense program. In that issue I pointed out that a military defense is not the only one. I said:

"On the contrary, the best and surest way to perfect a lasting defense for democracy in this country is to develop well-educated citizens. *The Mathematics Teacher* believes that the right kind of mathematical education is an integral part of the training of every citizen whether he is to take any part in the military, naval, or technical aspects of the defense program. If a person is to have an active part in the present defense program in the army, navy, or some technical department of the defense program, it is all the more important that he should have had a certain amount of mathematical education.

"All of this shows how in peace time we cannot reduce the amount of actual mathematical training of each boy and girl, particularly the boy, to the narrowest kind of minimum because we never know at any time what demands the future is going to make on our citizens. For this reason and for many others the leaders in general education, to say nothing of the leaders in mathematical education, should be careful about reducing the amount of required mathematics to too small a minimum. In this connection all of our readers should read Walter Lippmann's article in the Spring 1941 issue of *The American Scholar*."[3]

The Universality of mathematics. People generally do not realize

[3] Page 230.

the universality of arithmetic in particular or mathematics[4] in general. Our task is somehow to develop a generation of teachers who not only know a great deal about their own field of study, but who also understand something of the "wider ranges which make up the rest of life." The trouble is not so much with mathematics as some of our critics would have us believe.[5]

Students in other fields as well as in mathematics have, for one reason or another, developed a very unfortunate emotional complex against the simple elements of mathematics, and this causes no end of trouble for the teacher who later finds such students in any course of his which involves a knowledge of such mathematics. In a report on the mathematics that is necessary to do acceptable work in college courses in statistics[6] in the United States, it was pointed out that many simple arithmetical and algebraic tasks are not easy for many graduate students. A large percentage of almost 1000 students who took an inventory test were utterly unable to do some very simple exercises, the ability to do which is very essential for a successful knowledge of educational statistics.

It is most interesting and also instructive to note that it took a World War to make the American people generally realize that basic mathematical instruction in the schools of this country was woefully deficient. Many of us knew a long time ago that such conditions existed. Leaders in the educational field had previously pointed out the shortcomings, but the deficiencies thus disclosed did not at the time seem to be so tragic because the public was not made aware of the possible dire results of such a sad state of affairs, as then existed. Knowledge of arithmetic in particular and of mathematics in a broader sense was not necessary to protect our freedom, or at least we did not realize that it was necessary, and so nothing much was done about it.

When Admiral C. W. Nimitz wrote the now famous letter to Louis J. Bredvold, a member of the University Advisory Committee on Military Affairs at the University of Michigan, criticizing severely the inadequate preparation in arithmetic of the Navy recruits that had then come to his attention, he started something that even he probably did not expect to happen.

Admiral Nimitz had previously visited the university and had "mentioned that there had been some difficulty in finding students in American Colleges, other than engineering colleges, who were sufficiently prepared in mathematics to make them available for training for Commissions in the Navy." Bredvold thought that the situation

[4] Reeve, W. D., "The Universality of Mathematics," *The Mathematics Teacher*, February, 1930.

[5] *Mathematics in Modern Life*, Sixth Yearbook, National Council of Teachers of Mathematics, 1931.

[6] Brown, Ralph, *Mathematical Difficulties of Students of Educational Statistics*, Bureau of Publications, Teachers College, Columbia University, New York, 1933.

"ought to be called to the attention of educators in colleges and secondary schools throughout the country." Accordingly, he wrote to Captain Lake, Head of the Training Division, Bureau of Navigation, Washington, D. C. saying in part:

"I should deeply appreciate receiving a statement from you on this matter especially if you could give me such facts and figures as would constitute a self-evident argument. I hope also that it will not be necessary to set any restrictions on the use of such information. It seems to me that educators should promptly recognize the danger, if there is any, from our past softening of our educational programs."[7]

In his reply Admiral Nimitz said among other things:

"A carefully prepared selective examination was given to 4200 entering freshmen at 27 of the leading universities and colleges of the United States. Sixty-eight per cent of the men taking this examination were unable to pass the arithmetical reasoning test. Sixty-two per cent failed the whole test, which included also arithmetical combinations, vocabulary, and spatial relations. The majority of failures were not merely borderline, but were far below passing grade. Of the 4200 entering freshmen who wished to enter the Naval Reserve Officers' Training Corps, only 10% had already taken elementary trigonometry in the high schools from which they had graduated. Only 23% of the 4200 had taken more than one and a half years of mathematics in high school.

"This same lack of fundamental education presented and continues to present a major obstacle in the selection and training of midshipmen for commissioning as ensigns, V-7. Of 8000 applicants—all college graduates—some 3000 had to be rejected because they had had no mathematics or insufficient mathematics at college nor had they ever taken trigonometry. Almost 40% of the college graduates applying for commissioning had not in the course of their education taken this essential mathematics course.

"The experience which the Navy has had in attempting to teach navigation in the Naval Reserve Officers' Training Corps Units and in the Naval Reserve Midshipmen Training Program (V-7) indicates that 75% of the failures in the study of navigation must be attributed to the lack of adequate knowledge of mathematics. Since mathematics is also necessary in fire control and in many other vital branches of the naval officer's profession, it can readily be understood that a candidate for training for a commission in the Naval Reserve cannot be regarded as good material unless he has taken sufficient mathematics.

"The Navy depends for its efficiency upon trained men. The men are trained at schools conducted for this purpose and the admission of men to these schools is based upon the meeting of certain carefully established requirements. However, in order to enroll the necessary number of men in the training schools, it was found necessary at one of the training stations to lower the standards in 50% of the admissions. This necessity is attributed to a deficiency in the early education of the men involved. The requirements had to be lowered in the field of arithmetical attainment. Relative to the results obtained in the General Classification Test, the lowest category of achievement was in arithmetic."[8]

Of course, one would naturally question whether the mere fact that such recruits showed inadequate facility in common arithmetical operations was any *prima facia* evidence that these boys had not received careful instruction in the elementary school. Adults who

[7] "The Importance of Mathematics in the War Effort." An editorial in *The Mathematics Teacher*, February, 1942, 35:88.

[8] *Ibid*, pp. 88–89.

may have been very well taught by competent teachers may by disuse forget many of the skills that they may have established to a satisfactory degree of mastery.

It is only natural then that some people have questioned the validity of the Navy tests for judging the degree of mastery of skills previously taught to students in the schools unless perhaps, as has been done in some similiar situation, simple and brief review procedures were adopted for the purpose of improving the recall of certain items of skill. On the other hand, you and I know that, in general and in many particular instances, there is a large element of truth in the criticisms hurled at the schools by Admiral Nimitz.

In the future, we should insist upon the fact that initial learning which is not accompanied by a sense of pleasure in the process resulting in real understanding is not enough at any time, whether in war or in peace. Moreover, interest in and enjoyment of learning followed by complete mastery in the early years of one's active experience is never enough. No doubt many of the Navy recruits whom Admiral Nimitz tested as well as thousands of other American boys and girls learned many of the important arithmetical skills more or less by memoriter methods. The same thing is still going on in the schools even in algebra and geometry. Very little thinking is going on in the minds of entirely too many students in the schools.

The question of how the secondary school can adjust its curriculum to improve the abilities of its students and others in the community who may be needed in the armed services of this country is not as simple as the task facing the elementary school, but it is possible to make decided improvement. In attempting to find out how seriously we should take the criticisms of Admiral Nimitz and others, Brueckner conducted a National Survey, the complete results of which have been reported elsewhere. He said:

"The results of carefully constructed tests in mathematics administered to high-school seniors and men in the Army throughout the country reveal an unsatisfactory condition. For example, on a 30-item test in the four fundamental arithmetic operations on percentage, all of the skills included being judged socially useful, the median score for over 90 high schools in all parts of the country was 17.3 items correct, or 58% correct. Obviously, this is an unsatisfactory level of performance for those about to enter any branch of military life in which a fairly high degree of computational accuracy is desirable. The level of accuracy of a large group of Army Engineers was 85%, which might be regarded as a minimum standard for our schools."[9]

Brueckner further showed by a series of experiments that by a short period of intensive systematic practice with well-prepared ma-

[9] Brueckner, Leo J., "Testing Validity of Criticisms of Schools," *Journal of Educational Research*, October, 1943, 32: 465–468. See also Brueckner, Leo J., "Mathematics to Serve War Needs," *The Journal of the National Education Association*, October, 1943, 32: 203.

terials it is possible to produce a marked growth in arithmetic skill among high-school seniors.

Brueckner[10] also found that in the case of algebra there is a very large decrease in ability for students in the twelfth grade who have had only one or two courses in mathematics, usually algebra or geometry, or both, taken in the ninth and tenth grades.

The role of mathematics in the defense effort. How much influence Admiral Nimitz' letter had on the changed offering of mathematics in the schools no one can say. There is no doubt that in certain localities the effect was considerable. In some extreme cases too much and the wrong kinds of mathematics were undoubtedly taught and often to the wrong students. This is not strange in view of the way some people swing from one extreme to the other. Even those who had previously attacked mathematics as unimportant in the education of American citizens proceeded to insist that more mathematics be taught in the schools. As a result, all kinds of refresher courses were organized at various levels, some good and some bad, mainly in the senior year of high school, for those boys and girls who expected to be inducted into the armed services. One thing that we ought to keep in mind here is that one cannot refresh what he has not known.

The plan to induct boys of eighteen years of age into the armed forces of the United States affected very greatly the type of mathematics program offered in the secondary school. It is obvious that the kind of mathematics the boys needed to know to enter the various types of service had not been taught to all of them in later years. In fact, only a small percentage of them had taken the necessary amount. The schools, therefore, had to be reorganized with these needs in mind. The City of New York had regulations governing the intensive program of *war courses*, previously called *pre-induction courses*.

The step taken by New York City was no doubt followed by similar action elsewhere. This gave certain obvious results:

1. Secondary schools prepared boys and girls for the armed and allied services by offering required courses in mathematics.

2. Traditional mathematics, in the sense that overemphasis is placed upon formalism and deductive thinking, was greatly modified if not eliminated. This means that important applications of algebra and geometry were emphasized. Competence in arithmetic was stressed.

3. Students who had not already had a sufficient amount of mathematics were given a course in Basic Related Mathematics which

[10] *Ibid.*, p. 302.

was taken parallel with the required war courses (four in New York City).

4. Teachers from other fields had to be trained to teach some of the expanded mathematics program.

5. Textbooks were written to meet the needs of the emergency.

6. Whatever gains were made in the reorganization of materials for the war effort are supposed to be conserved for the peace that followed.

In some schools teachers of ability and practical experience as pilots gave training in air navigation to groups of students who knew definitely that they wished to go into the Air Corps and who had three years' or more experience in mathematics beyond the eighth grade. But such advanced technical courses should be offered only where it is clear that they can serve a good purpose and where the teacher is properly qualified to do the work.[11]

Thus, after several years of enforced retrenchment mathematics came to the front again as a fundamental part of secondary education because of its importance to the war effort. It is too bad that more people did not realize this sooner. Both the Army and the Navy demanded greater attention to the study of mathematics in the secondary school and pointed out the deficiencies in our recent program. However, the Army and Navy did not ask teachers in the secondary school to teach the more technical matters pertaining to war, but only the fundamental parts that should be included in any modern course. These branches of the service and Air Corps as well will train recruits in technical matters when they need them.[12]

Mathematics in an air-conditioned civilization. In this complex civilization in which we are now living school administrators and teachers alike are faced with the problem of providing a better type of education for the six million and more students who now make up the secondary school population. This means, not only drastic changes in the education of those students of the academic type to meet changing demands, but also an altogether different type of curriculum for those students who, under the traditional system, "leave school without skills or orientation of any kind with respect to social institutions."[13]

We have all heard the familiar remark, "We live in a changing world." The fact is that at the present time we not only live in a

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[11] See Moore, Lillian, "Aerial Navigation," *The Mathematics Teacher*, March, 1942, 35: 99–101.

[12] Venable, B. W., Colonel, General Staff, War Department, Washington D. C. "Education in the War Economy," *The Mathematics Teacher*, October, 1942, 35: 243–244. A speech by Colonel B. W. Venable, War Department, Washington D. C., which was delivered before the Annual Convention, American Association of School Administrators, on February 24, 1942, in San Francisco, California. See also Smith, Paul C., "The Navy and the School," *The Mathematics Teacher*, October, 1942, 35: 248–252.

[13] Judd, Charles H., "The Real Youth Problem," *School and Society*, January 10, 1942, 55: 32.

changing world, but the rate of change is so much more rapid than previously that few people are willing even to predict with any degree of precision just what will come to pass in the next fifteen or twenty years.

This generation and those that follow are going to be "air-conditioned," so to speak, and the sooner everybody adjusts his life to this situation the better for everybody concerned. The fact is that we must become air conditioned in order to survive.

The significance of all this for science in general and mathematics in particular is obvious to all who think seriously and fairly about the situation. These subjects, or at least their fundamental and useful aspects, should be *must* studies for most high school students in the days to come.

Those who have been thinking about the matter already realize that in any well-organized course in air navigation many of the principles of mathematics, physics, and the other sciences previously taught in the secondary school can be applied in ways that will make these subjects interesting, meaningful, and more useful than ever before. This does not mean that the schools should immediately go over to a program of war mathematics only to drop it when peace is assured. It means a careful reorganization of content material for teaching purposes which, after the emergency is over, will be just as useful in the day of peace that lie ahead. For, after all, the science and mathematics that go into the construction of an Army bomber is much the same as that necessary to build a commercial plane. We need to teach students the fundamental parts of the various divisions of mathematics that will equip them to make sensible applications in life in the most efficient manner.

Applications of mathematics to aeronautics. Here are some illustrations of the possible applications of mathematics that may be made to aeronautics at the present time on the secondary level.

The fundamental processes with integers and fractions both common and decimal which can be taught in the first six grades of the elementary school will furnish a basis for the real applications which should follow in the secondary school. Arithmetic itself has changed greatly. It is now dynamic where formerly it was static. It now deals with automobile tires, airplanes, and the like. The subject correlates well with algebra, informal geometry, and numerical trigonometry all of which are very important in solving the problems of air navigation.

Aviation furnishes many interesting illustrations. For example, for any given speed, there is a certain altitude above ground at which a plane can fly in a circle around a *pylon* (or point on the ground) at the proper degree of bank with the lateral axis pointing directly

toward the pylon at all times. This particular altitude is called the *pivotal altitude* for that particular speed. The greater the radius the less the necessary bank, but at the pivotal altitude the lateral axis can always point directly toward the pylon.

The formula[14] for the pivotal altitude is $P.A.=0.067A^2$ in which $P.A.$ is the pivotal altitude in feet and A is the speed of the plane in miles per hour. Thus, the pivotal altitude varies as the square of the speed. If the speed is doubled the pivotal altitude is quadrupled. If $A=100$ mi/hr, $P.A.=670$ ft., and if $A=200$ mi/hr $P.A.=2680$ ft.

Obsolete problems in algebra should be replaced by problems about when, under certain specified conditions, two airplanes will meet, or how long it will take an airplane to perform a certain specified function and then return to the carrier from which it took off in the first place. Such problems are found in the book referred to above, and also in other recent books.

The law of "The Parallelogram of Forces" and the theorems relating to similar triangles are both very important and useful in air navigation and should be taught in the geometry course in such a manner that useful applications can be made by the students. Scale drawings (an application of the idea of similar triangles) are commonly used in all navigation problems. Very little is done with such things in the mathematics classes in most schools.

Great use is also made of graphic charts of all kinds, both statistical and mathematical graphs, in air navigation. A great deal of this work is elementary and yet it is most important. It should receive more attention in secondary schools. Moreover, the work should be begun in the seventh grade.

For most of the problems of aviation included in a recent book[15] a straight-forward application of sines, cosines, and tangents is sufficient. For example, suppose we take the simple but meaningless problem sometimes found in textbooks:

If the angle of elevation of a cloud bank as seen from a point A on level ground is 47°, what is the height of such a cloud directly above a point B?

Finding the height of such a cloud is now not only a real but an important problem in aviation and it can be solved by the use of a simple trigonometric formula.

These few illustrations will give a fairly complete idea of the range of mathematical applications in the aviation field. It is hoped that all teachers of secondary mathematics will begin to include such simple problems in their courses.

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[14] Pope, Francis, and Otis, Arthur S. *Elements of Aeronautics*, World Book Company, Yonkers-on-Hudson, New York, 1942, p. 23.

[15] *Ibid.*

Now, when someone remarks that the Army, the Navy, or the Air Corps says that certain conditions exist and that this or that thing should be done about it, what does he mean? He probably means that some individual among the Army or Navy personnel gave such and such an opinion about the situation. However, we know in general that the armed forces think that the proper teaching of mathematics and science has been neglected in the school, and the preceding quotations are representative of the attitude toward what should be done in mathematics in the secondary schools. The attitude of the leaders in the field of Civil Aeronautics is quite similar. They feel that the main business of the teacher of mathematics is to teach a modern course in the fundamentals of mathematics, general mathematics, if you please, making such use of these fundamentals in applications[16] to science, air and marine navigation, and war industries as time and the ability of the teacher and students permit.

III. The Future Situation in Mathematics

To make mathematics education function at its highest in this country we need to evaluate anew not only the materials of instruction, but also to improve methods of teaching and learning mathematics. The improvement of content makes necessary a reshaping of aims and the development of a new nation-wide cooperative program. The improvement of teaching and learning will involve the raising of standards for teachers entering the profession and improved opportunities for the further education of teachers in service.

Another significant factor is the fact that our unprecedented industrial and economic growth has resulted in men leaving the teaching profession to go into other lines of work. The exodus of male teachers is not only large, but alarming. Even women are leaving the teaching profession to take up some other type of work. While we may admit the natural superiority of women with children, we must not fail to realize that for many women teaching is not a permanent profession. What is the mental effect? I think it has led to a lack of interest in the proper preparation and background for teaching mathematics in the schools. As a result we do not have among either men or women teachers enough people of scholarly minds. The mathematical background of many of our teachers is decidedly limited, to say nothing of their deficiencies along other lines.

Many people are teaching mathematics in the secondary schools who have not had any mathematics courses of collegiate grade. The

[16] *A Sourcebook of Mathematical Applications*, Seventeenth Yearbook of the National Council of Teachers of Mathematics, 1942. This book is excellent for supplementary teaching materials. See also a very helpful book for supplementary applications by George Osteyee, *Mathematics in Aviation*, The Macmillan Company, New York, 1942

situation is even worse than that in some places. When a superintendent of schools insists on putting a teacher, who has had no mathematical training, in charge of high-school classes in mathematics because he has no other use for him, the situation is terrible. Even now when the shortage of teachers is so acute, the policy of selecting people, who are not prepared, to teach mathematics may be worse than no teacher at all, unless of course they are gifted and seek immediate preparation. The National Council of Teachers of Mathematics should begin to study such practices and make plans to improve them. We could do this if we had sufficient group consciousness, group enthusiasm, group loyalty, the courage of our convictions and some financial help.

If we are to require better trained teachers, we must insist that salaries be increased. The low salaries paid to teachers in the schools is a national disgrace. We must attract more people, especially men, into the teaching profession by paying them salaries equal to what they can get in business and industry. Some kind of minimum standard should be maintained if we are not to be further embarrassed by the performance of the youth who go through the secondary school.

It now seems pretty clear that if mathematics is to continue to hold the high place it now occupies among the great fields of knowledge in the secondary school curriculum and in the public esteem the following things must be kept in mind and something worthwhile should be done to carry out the improvements and changes suggested by them:

1. *Arithmetic in the elementary school must be reorganized for teaching purposes and those who teach it should be required to know more about the subject than many teachers do at the present time.*

2. *Prospective teachers must be better trained to teach mathematics in the schools and those who are already teaching should be improved while they are in service.*

a. Two types of scholarly men and women should be developed: First, research scholars whose major interest is to expand mathematics vertically; second, "teacher scholars," as Bagley called them, who are primarily interested in the horizontal expansion of the subject.

b. We need courses in methods and in professionalized subject matter for students who intend to be college teachers of mathematics. The teaching of college mathematics in many places is far below a desirable standard.[17]

3. It seems to me that we might require some training in science, at least in physics, of all prospective teachers of mathematics. In

[17] Seidlin, Joseph, *A Critical Study of the Teaching of Elementary Mathematics*, Bureau of Publications, Teachers College, Columbia University, New York, Contributions to Education, No. 482, 1931.

some schools the work in mathematics is already being correlated in this way.

4. We must cooperate with subject matter specialists in other fields in demanding more recognition on the programs at such general educational meetings as state associations, sectional meetings, and teachers institutes. Some state associations are so completely under the control of secretaries (often men of meager academic training), that it is almost impossible for a subject matter group to secure any outside talent without themselves providing the necessary funds. As Pierce puts it,

> "Convention speakers rarely present a topic which has even remote value to the teacher's problem in the classroom. Most of them advance their pet theories, discuss their research work, or talk about economic or political problems with which they are none too familiar. Most teachers go to conventions to receive instruction on the nature of the child and his proper nurture. High sounding phrases, patriotic oratory, or research dissertations hold little of interest and less of value to the average teacher."[18]

5. *Those who teach mathematics must find out not only how students learn but how they learn most easily and effectively.*

This implies a new emphasis upon meaning and understanding and less upon mere skill and the automatic functioning of principles of operation. *Speed* is important, of course, in learning the skill operations, but *accuracy* is the more important goal. It involves the whole question of the transfer of training about which so much has been said and written in recent years, but about which very little has been done in so far as the improvement of learning is concerned.

6. *The unusual emphasis which is being given to mere practical applications without connecting them with underlying mathematical principles should be reduced.*

If we accept the premise that in a democratic society each individual be given the opportunity to develop his potentialities as fully as possible, then it follows that the main emphasis should be placed upon the importance of the more general application of principles for a large number of students.

This does not mean that practical applications will not be made, but they should be made for purposes of motivation and in cases where such applications will help the student better to understand basic ideas and how they can be transferred to real life situations.

As in arithmetic, so in the other mathematical subjects in the secondary school, certain omissions and additions would be helpful along with a renewed attempt to make mathematics not only more interesting, but more useful by the introduction of more realistic

[18] Pierce, A. Lester, "Why Teachers Duck Conventions," *The Clearing House*, November, 1943.

applications all along the line. These applications of the essentials should be made to genuine problems in the fields of science, industry, air and marine navigation or other work of importance at the time.

7. *Much greater attention need to be given to the matter of individual differences in ability among students in the schools.*

The administrative problem is somewhat different in the large city and the smaller town schools and it is not easy to solve, but it is a challenge to the best thinking we can do.

Individual differences in ability among students are now generally recognized, but little is being done to reorganize the content material for teaching purposes to meet them. For example, we have been advised by leaders in the field and, notably, by the Commission on Post-War Plans in its "Second Report" about the importance of a "second track" for students not going to college, or at least for students for whom the traditional course in mathematics is neither of interest nor of much value.

Some people say that to classify students into homogeneous groups is undemocratic. This cannot be proved by the facts. In a democracy, if anywhere in the world, leadership is essential, but it is also necessary to have intelligent followership. This can never happen to so great an extent as we might have with better class organization.

We can partly allay the fears of some people by making sure that in the main stream of knowledge we guarantee that the students have common experiences (the democratic way) and that enrichment in mathematics be offered for those who are able to take it.

All students in the high school, girls as well as boys, should be advised to study mathematics according to their ability and needs. For somes perior students or for those entering certain technical or professional lines of work this will mean four years. For the remainder of the students two or three years of general mathematics if properly organized may suffice.

What, then, should such a course contain? For explicit details the reader should consult the forthcoming issues of journals like *The Mathematics Teacher* and SCHOOL SCIENCE AND MATHEMATICS and the yearbooks of The National Council of Teachers of Mathematics which deal with such matters. Outlines and textbooks covering the work of such a course are already beginning to appear and more will follow.

8. As fast as we improve the teachers of mathematics, we can lift the level of the articles in the various mathematical magazines. However, we shall still face the problem of getting these journals in the hands of teachers where they will be more widely read.

9. *Mathematics teachers need to work in closer cooperation with teachers in the other great fields of knowledge.*

If the *Core-Curriculum*[19] idea is to have any chance of success, something must be done to make teachers generally more scholarly. However, the idea that one teacher can correlate all of the various subject-matter fields and teach them in the classroom is too ridiculous for comment here. It is not only possible but desirable to have the teacher of mathematics teach science, particularly some physics, or mechanics, or both. There are many teachers who can bring out relations between mathematics and art, between mathematics and music, and so on, but, generally speaking, such teachers are rare. What we need is a careful and more scholarly approach to the solution of this problem of correlation.

10. *Teachers of mathematics in the colleges and universities need to take more interest in the work of the secondary schools.*

We have a few outstanding cases[20] of teachers in the colleges and universities who have taken great interest in the work of the secondary schools and in organizations of teachers in secondary schools, but for the most part many of these people do not know what is going on in the schools and some of them seem to care less.

There is a great need for a better working understanding and cooperation between teachers of mathematics in the secondary schools and those of collegiate grade.

11. *Coordinating high school and college mathematics.*[21]

The problem of coordinating high school and college mathematics is one in which both high school teachers of mathematics and college teachers of the same subject should cooperate in solving. Failure to coordinate these separate fields in the past has led to a great deal of confusion and genuine loss both to the students involved and also to their teachers.

What is even worse so far as the students, and even their teachers, are concerned is for the students to neglect mathematics in the high school and then have to take algebra, trigonometry, or other strictly high school mathematics courses in the colleges and the universities, and thus often miss analytic geometry and the calculus.

I believe that much of the trouble we have is due to a lack of cooperation between those who should be most vitally concerned with the training of the mathematics teachers of the future. The college and university professors of mathematics and related fields have not been enough concerned about the education of teachers in their fields and as a result what should have been the duty of these professors

[19] Fawcett, H. P., "Mathematics and the Core Curriculum," *The Mathematics Teacher*, January, 1949, 42: 6–13. See also Jansen, H. S., "The Relation of Mathematics to the Core Curriculum," *The Mathematics Teacher*, October, 1952, 45: 427–435 and Syer, Henry W., "A Core Curriculum for the Training of Teachers of Secondary Mathematics," *The Mathematics Teacher*, January 1948 , 41: 8–21.

[20] Notably, H. E. Slaught, E. R. Hedrick, Edward Kasner, and G. A. Mitchell.

[21] Reeve, W. D., "Coordinating High School and College Mathematics," *The Mathematics Teacher*, December, 1946, 39: 354–364. See also *The American Mathematical Monthly*, January, 1947, 44:1–10.

has been usurped by professors of education. As a result a sort of bad feeling has grown up.

The following quotation from Hedrick will make clear what is involved:

"That there is a spirit of uncompromising opposition, not to say hostility, on the part of many academic men toward all that calls itself education may as well be admitted. That there is equally blind and doctrinaire opposition to all mathematics on the part of some educators is all too patent. Cooperation between forces thus not only separated, but even—in the minds of many—fundamentally opposed, may seem indeed visionary.

"On the other hand, however, I believe that intelligent minds dealing with the the same data will, in the end, reach results that are approximately in unison. Nor is intelligence lacking, as the more fanatical in either group might hold, on either side. What is lacking to a far greater degree is a sincere desire to know the sound views of the best thinkers in the group not one's own. Men in mathematics (or in any other academic subject) read infrequently any educational literature; they learn usually only of these flambuoyant excesses of statement which attain newspaper notoriety; these do not represent, ordinarily, the best educational opinion. Men in education read little that is written by subject-matter teachers, nor do they commonly hear such men speak in their conventions. It seemed to me to be an excellent sign of a better era when Dean Uhl, secretary of Section Q (Education) of the American Association for the Advancement of Science, informed me that the council of that section had passed formal resolutions at the Washington meeting in December, 1931, to secure subject-matter teachers as speakers in part, at such meetings of educators.

"There is, I think, some danger that our prospective high school teachers of mathematics will be required to take too many general courses in education when we know that special training in their fields is more urgent. Or to put it in another way. There is danger that prospective teachers will be required by over-zealous educators or state governing bodies to take the wrong courses in general education. Merely taking a course signifies little. If some prospective teacher asked me whether he should take courses in education, I should want to know first, what the course was, and second, who was giving it. It strikes me that the person who gives the course in question is the important thing here. However, we must have cooperation."[22]

To quote Hedrick once more:

"Glorifications of mathematics that claim for it a subtle alchemy that is to cure all mental ills display total disregard for the simplest and best proven of all the results of modern psychology. Condemnations of every variety of mathematics are equally futile; they ignore the fact that modern civilization and life is largely quantitative in character, or else they assume definitions of mathematics which do not include its principal function: the training in thinking about quantitative situations.

"Scientific study demands dispassionate approach. Oratory is conspicuously lacking in that quality. Those who show unreasoning animosity, be it mathematicians in their attitude toward emotional principles, or educationists in their attitude toward mathematics, disqualify themselves by that fact alone from any participation in a real solution of the problem of the teaching of mathematics in the schools.

"The eventual solution of the problem of mathematical teaching in schools of all grades depends upon the condemnation of such practices by each group

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[22] Hedrick E. R., "Desirable Cooperation Between Educationists and Mathematicians," *School and Society*, December 17, 36: 769–777. See also Langer, R. E., "The Things I Should have Done I Did Not Do," *American Mathematical Monthly*, August-September, 1952.

and upon the formation of a working body of men from both of the groups who will forego prejudice and group interests, and who will strive to establish, not by orations before audiences, but by dispassionate study, common principles in education and in mathematics that are true, lasting, and thus acceptable to all intelligent persons.

"To be qualified for cooperation in such work a mathematician need not be versed in educational principles, but he should not be one who announces disbeliefs in any and all principles of education. To be qualified for such cooperation, an educationist need not be highly trained in mathematics, but he should not be one who decried mathematics without a hearing, nor one who violates educational principles by defense of such practices as those that I have described."[23]

That the situation in regard to the outcome of instruction in mathematics is not yet satisfactory is evidenced by such present day statements as the following by Professor Cairns of the University of Illinois who recently said:

"Mathematicians have played a leading role in efforts over the past fifty years to encourage the teaching of mathematics so as to appeal to the imagination and awaken the interests of students. Further success in these efforts, in which professional educators have cooperated, will depend on training public school teachers so that they acquire a genuine appreciation for mathematics and that their understanding is developed well beyond the level at which they are expected to teach. Under present conditions many of them dislike and fear the subject and unconsciously transmit their feelings to their students."[24]

Cairns goes on to say:

"Even in peaceful times, the demands of society for engineers and scientists would be very heavy. As matters now stand, however, we need hardly be reminded that our national security hangs in the balance, and that in the desperate struggle to preserve it, mathematics and science are crucial weapons. Our educational shortcomings are thus revealed not only in the light of a national disgrace, but also as a dangerous source of weakness on the international front."[25]

Such criticisms are not directed only at the present teaching of mathematics in the schools. Bestor in speaking to the Council of the American Historical Association proposed a set of resolutions in which after expressing great concern over the anti-intellectual tendencies in the schools, he asked his colleagues to cooperate in an attempt to improve the situation. He said:

"The American Historical Association stands ready, as it has always done, to cooperate with Educational Administrators in advising sound public-school programs in history and the social studies. It is alarmed, however, at the growth of anti-intellectualist conceptions of education among important groups of school administrators and educational theorists. Such conceptions have led, in many instances, to public school curricula in which intellectual training has been pushed into the background, to teacher certification laws and rulings that dangerously underemphasize training in the subjects to be taught, and to pronouncements to the effect that the intellectual criteria employed by scholars and scientists are inapplicable in the public schools. To the degree that such anti-intellectualist conceptions gain headway in the public-school system, the

[23] *Ibid*, p. 773.

[24] Cairns, S. S., "Mathematics and the Educational Octopus," *Scientific Monthly*, April, 1953.

[25] *Ibid*.

possibility of fruitful cooperation between scholars and professional educators grow smaller."[26]

Breslich,[27] one of the great teachers of this generation, lists the characteristics that he thinks a good teacher should possess as follows:

1. The good teacher of mathematics has acquired a thorough academic and professional preparation. He never ceases to grow in the field of his choice.
2. He is qualified to teach at least one subject other than mathematics.
3. He is familiar with the uses of mathematics in practical fields.
4. He is a master of the most effective teaching techniques.
5. He has cultivated such important traits as the following:

a. He is loyal to his subject, school and pupils.

b. He is an enthusiastic teacher even when he has to work under unfavorable conditions.

c. Teaching is a profession in which he takes great pride.

d. He is conscientious about his work.

e. He is resourceful in ways of meeting class room problems.

f. He has a sympathetic attitude toward his pupils.

g. He possesses genuine interest in his subject and passes it on to the learner, because he is efficient.

h. He is popular with his pupils and their parents.

i. His standards of accomplishments are high.

j. He is just and fair in his relationships with children.

k. He sells his subject to pupils and their parents.

If the preceding ideas are carried out, we ought to look forward to a renaissance in teacher training. The problem is one for serious consideration by the National Council of Teachers of Mathematics, The Mathematical Association of America, and even the American Mathematical Society.

How can different points of view be reconciled? We now come to the main point of the problem, namely, how can such a parently diverging points of view be reconciled?

James Bryant Conant formerly president of Harvard University has made an excellent suggestion. In discussing the reasons why the lay critics of secondary education talk as they do, Conant said:

"I am almost tempted to generalize that the more educated the person, the less his knowledge of secondary-school education. Certainly the lack of knowledge among the professors of arts and sciences in our colleges and universities

(*Continued on page 635*)

[26] Bestor, Arthur E., Jr., "Aimlessness in Education," *Scientific Monthly*, 1952, 75: 109–116. See also Fuller, H. J., "The Emperor's New Clothes," *Scientific Monthly*, 1951, 72: 32–41.

[27] Breslich, E. R., "What Makes a Good Teacher of Mathematics?," *Scripta Mathematica*, September, 1953.

HIGHLIGHTS OF THE 1953 CASMT CONVENTION

All of you, undoubtedly, read with interest General Omar Bradley's article in two of the fall issues of the *Saturday Evening Post.* In this article General Bradley emphasized and re-emphasized the importance of scientists in preserving our democratic way of life. He also pointed out the responsibility that teachers and educators have in assisting and interesting young people to pursue the study of science and mathematics.

As teachers we have been keenly aware of the world's need for scientists and their importance in preserving the democratic way of life. Let us make our neighbor aware that we have assumed this responsibility and enlist his support. At the same time let us see if we can find additional ways in which we can help our young people carry on this important task.

The 1953 Convention of the Central Association of Science and Mathematics Teachers was planned with these things in mind. "Stimulating Interest in Science and Mathematics" is the theme of the convention.

Dr. Joseph C. Boyce, Associate Director of the Argonne National Laboratories, will speak, Friday morning, November 27, 1953, on "The Neutron and Modern Alchemy." This you will not want to miss. Dr. Boyce has told us that he would welcome a discussion from the floor following his talk.

At the luncheon on Friday, November 27, Dr. Gustav Egloff will speak on "The Impact of Industry on Science." This really will be one of the highlights of the convention. Make your reservation now. Complete and mail the Luncheon Reservation Blank published in this issue of the journal, SCHOOL SCIENCE AND MATHEMATICS, page 633.

Saturday morning, November 28, 1953, we will get the educator's point of view when Dr. Earl K. Peckham will discuss "Can the School Serve Its Time?" This discussion will be provocative and one you will want to hear. It will cause you to stop and re-examine your own teaching.

The Sections and Groups have splendid programs planned. One example is the Conservation Group. At this meeting Dr. Rudolph Novick will discuss "Human Conservation and Mental Health" and Dr. Lanis Katz will discuss "Animal Experimentation and Human Heart Disease." There are many other equally outstanding papers and talks which you will find extremely stimulating.

Make your reservation now. A brief outline of the general program of the 1953 CASMT Convention appears elsewhere in this issue of the journal. Also consult your copy of the 1953 CASMT Yearbook.

That carries all the details of the convention. We will look for you at the Congress Hotel, Chicago, Illinois, November 26–28, 1953.

CASMT LUNCHEON MEETING—FRIDAY, NOVEMBER 27, 1953

Send reservation to

Mr. Ray C. Soliday, Treasurer and Business Manager
Box 408, Oak Park, Illinois

Please reserve _____ tickets for luncheon @ $3.25 each

Enclosed find check or money order for $_____

I prefer: Fish _____ Meat _____

Signed _____ Date _____

Address _____

_____

1953 CONVENTION OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS

CONGRESS HOTEL, CHICAGO—NOV. 26–28, 1953

GENERAL PROGRAM

Friday, November 27, 1953

9:15 to 9:35 Final Report of Project: Significance of Mathematics and Science in Education
Dr. George G. Mallison, Western Michigan College, Kalamazoo, Michigan

9:40 to 10:30 The Neutron and Modern Alchemy
Dr. Joseph C. Boyce, Associate Director of Argonne National Laboratories

10:45 to 12:00 Section Meetings
Biology
Chemistry
Elementary Science
Mathematics

12:30 to 2:00 LUNCHEON—Glass Hat
The Impact of Industry on Science
Dr. Gustav Egloff, Director of Research, Universal Oil Products Company

2:30 to 4:00 Section Meetings
Elementary Mathematics
General Science
Geography
Physics

4:30 Exhibitors Demonstrations

4:30 & 7:00 Convention Committees meet. You are welcome to attend.

See 1953 CASMT Yearbook for details of the Convention Program

Saturday, November 28, 1953

9:15 to 9:30 Report of CASMT cooperation with the Cooperative Committee on the Teaching of Science and Mathematics of A.A.A.S.
Donald Lentz, Parma, Ohio, CASMT representative to Cooperative Committee

9:30 to 10:30 Can the School Serve Its Times?
Dr. Earl C. Peckham, Director of Materials Division, Federal Civil Defense Administration, Washington, D.C.

10:30 to 11:00 Business Session

11:00 to 12:00 Group Meetings
Conservation
Elementary School
Junior High School
Senior High School
Junior College

1:00 to 3:00 Board of Directors Meeting

See 1953 CASMT Yearbook for details of the Convention Program

Send in your LUNCHEON RESERVATION to
Ray C. Soliday, Treasurer and Business Manager
Box 408, Oak Park, Illinois

REFLECTIONS ON JUDGING A SCIENCE FAIR

JULIUS SUMNER MILLER

On Friday, April 17, I had the very great honor of judging the Science Fair at the Los Angeles County Museum. The exhibitors were school kids from grades 7 through 12. Over 200 exhibits were on display, demonstrating facts and theories and phenomena in a wide range of science. The skill and ingenuity and imagination of these youngsters stirred me. The work was all their own; the ideas were all their own; the *imagination* was all their own. The judges were hard-put to make decisions. In my own thinking ALL the kids deserved prizes and awards. Now how do these things stand in the larger scheme of our way of life? It is to this point that I wish now to address myself.

It is well known that Hitler might have conquered the world had he not so brutally treated his scientific talent. As it was, he did surprisingly well by the efforts of those who, under duress and compulsion, saved their lives by adopting the Nazi ideology. Here in this land such action is unthinkable but I still feel that we are neglecting an important section of our population. These young kids who show such promise should be provided with special instruction and their imagination should be given freer rein. I am mindful that, democratic-wise, we have a responsibility to the thousands who need the basic instruction. This we provide quite nobly. Indeed, we provide quite generously for the slower-witted. By these I really mean the normal! Kids like you and I were! But we do not, in my opinion, provide generously enough for the gifted. Every one of these youngsters who put his stuff on display is gifted. The mere fact that he had the spirit and the drive and the purpose points this up. Out of a school population of hundreds of thousands a bare 200 or so demonstrated the temper and the imagination that sets aside the thinker and the doer. Who knows but what among these lives another Faraday or another Pasteur. We are "missing the boat" unless we attend to these.

Withal I come to another reflection. This talent, so nobly demonstrated by these kids, will prevail and produce in spite of our neglect. Energy like this is not easily put down. And as long as it resides, even only in a small fragment of our total peoples, we need have no fear for the destiny of this land.

(*Continued from page 631*)

is proverbial. And with lack of information goes lack of understanding and lack of sympathy. As a result, on more than one campus we have almost a state of civil war between those who profess a knowledge of education and those who profess a knowledge of subjects which constitute a modern educational curriculum.

"This academic war has been in a sense inevitable, as I propose to show by a brief resume of history, but to my mind an armistice has been for some years overdue. And it is for such an armistice that I should like to put in a good word this afternoon (and I might remark parenthetically that it takes two to make an armistice quite as much as to make a quarrel). My belief in the need for the cessation of hostilities comes not only from my general tendency to favor pacific methods of handling academic controversy, but also because I am really worried about the present lay reaction to educational matters. I am distressed by both the vehemence and the ignorance with which views about education are expressed publicly and privately by many prominent people. Now we can hardly expect the public to have a very clear understanding about educational problems when education is a house warring against itself. Hence my plea this afternoon for a 'cease firing' order."[28]

When teachers of secondary mathematics, college mathematics, supervisors, administrators, and general educationists sit down around the table to discuss what, for all of them should be a common problem, then we can hope for some practical solution of what shall constitute general education. A good preparation for such a procedure for all those who are interested in what the content of mathematics should be is a most careful reading of the entire articles referred to above as well as of some which I have not had space to mention.

The next move. The Central Association of Science and Mathematics Teachers and other similar organizations know that the mathematics in the schools should be reorganized for teaching purposes, and a great deal of time and energy have been spent in preparing articles, yearbooks, and reports to help ameliorate the situation. This is all to the good. The next move should be to perfect some plan to offset much of the unfair and unsound criticism that is being leveled at the teaching of mathematics, and then to see to it that something is done to guarantee that the recommendations of the recent reports of national commissions on mathematics may have a chance of being adopted in the schools.

Unless the work of such commissions as those mentioned above are carried on continuously by the teachers of mathematics, much of their work will have been in vain. After all, the mere fact that reports are made settles nothing one way or the other. If teachers do

[28] Conant, James Bryant, "A Truce Among Educators," *Teachers College Record*, December, 1944, 46: 157–163. See also his article, "Why Not Bury the Hatchet?" *N.E.A. Journal*, May, 1951, 40: 352.

not read the reports and then do something, little progress will be made.

What groups of American citizens then are likely to need further training in mathematics in the days ahead and what types of organizations of subject matter and methods of instruction are likely to prove most efficient?

12. *The mathematics of the junior high school years (7 to 9 inclusive) must be completely reorganized.*[29]

If and when we finally realize the importance of this apsect of mathematical training for youth, the teacher-training institutions throughout the country must include such work as a part of their required training for all teachers in both the junior and senior high schools.

13. *Senior high school mathematics must also be reorganized. It should be a continuation of the general mathematics program of the junior high school.*

The question as to what should be the content material for the senior year of the high school is still somewhat unsettled, but some good plan can be worked out that will be better than what we have at the present time.[30]

[29] Coleman, Robert., *The Development of Informal Geometry*, Teachers College, Columbia University—Contributions to Education, No. 865. New York, 1942.

[30] *The Place of Mathematics in Modern Education*, Fifteenth Yearbook of the National Council of Teachers of Mathematics, 1940, pp. 246–253. Here is a grade placement chart that is very helpful. See also *Functional Mathematics in the Secondary Schools*, Bulletin No. 36, State Department of Education, Tallahassee, Florida, and McDuffee, C. C. What Mathematics Shall We Teach in the Fourth Year of High School?" *The Mathematics Teacher*, January, 1953, 45: 1–9.

JOHN H. WOODBURN JOINS NSTA STAFF

Dr. John H. Woodburn, Assistant Professor of Science at Illinois State Normal University, joined the NSTA staff August 17 to begin his duties as Assistant Executive Secretary. He will have chief responsibility for the Future Scientists of America Foundation activities and projects but will render service to the Association in other ways as well. He has also accepted a part-time appointment to the staff of McCoy College of the John Hopkins University in Baltimore.

Rapid expansion of the FSAF program necessitated this staff addition. Financial support of FSAF by business and educational groups has made it possible. First call upon Woodburn's time and talents will be the summarization and publication of findings from a research study concerned with programs of incentives, awards, career information, and specialized study opportunities for high school science students and teachers. The study involves two aspects of the problem: (1) the extent to which science teachers are alert to and make use of such services, materials, and programs; (2) the extent to which non-school groups provide such services and materials.

Woodburn is eminently qualified by interest, training, and experience to undertake his new duties. He has long been active in NSTA; is a member of the Advisory Council on Industry-Science Teaching Relations and has served as a Packet Service evaluator. Following several years' experience as a science and mathematics teacher in Ohio high schools, he completed his Master's degree at Ohio State University. His undergraduate degree was obtained at Marietta College.

LEARNING THE SCIENTIFIC METHOD THROUGH THE HISTORICAL APPROACH[1]

AARON J. IHDE
University of Wisconsin, Madison, Wisconsin

Science, in contrast to certain other academic disciplines, has an accumulative character. In order to gain advanced knowledge in science it is necessary first to gain a mastery of basic fundamentals. It is then possible to build on these fundamentals to ever higher levels of understanding. At the same time that the student is faced with the need to master fundamentals he sees around him a science which is expanding its horizons at an ever increasing rate, a rate that has become alarming to many during the past half century. The horizons often look more tempting than the more earthy fundamentals.

The science teacher is faced with the problem of creating a course which does not allow the horizons to take precedence over the solid footing underneath. It is difficult to select judiciously from the wealth of material available for study so as to achieve a balance between the new and spectacular on the one hand and the basic but less exciting on the other.

In the final analysis, care must be used to avoid being overcome by the abundance of new material available or our courses become superficial. As science teachers we must face two major obligations—to offer a course representing respectable intellectual activity and one which develops an understanding of and appreciation for the scientific approach toward the problems posed by nature. The first obligation should be taken for granted in academic circles. The second is the subject for this discussion since it represents the area where science teachers can make a unique contribution.

In encountering the problem of scientific approach or scientific method we are justified in raising the question, "Just what is scientific method?" Rather than present you with an authoritarian definition to settle the matter I must submit that I really don't know. It is something like trying to define democracy, or truth. It is the sort of thing that all of us tacitly assume to exist, that we work with, but which we hesitate to define and which we really don't understand. The question has been baffling to some of our greatest scientists and our greatest philosophers. Nobel laureate P. W. Bridgeman has said, "I am not one of those who hold there is a scientific method as such. The scientific method, as far as it is a method, is nothing more than doing one's damnedest with one's mind, no holds barred. What

[1] Presented at the Conference on Teaching of Science held at the University of Wisconsin, Madison, Wisconsin, on July 14–16, 1953.

primarily distinguishes science from other intellectual enterprises, in which the right answer has to be obtained, is not the method but the subject matter."[2] I am not even sure that the scientific method should be called scientific. Although it has been used in science with unique success during the past three centuries I cannot feel sure that it is unique to science. I wonder if it isn't a common sense approach to problem-solving which has been used with variable success throughout man's intellectual history.

We are all familiar with the often cited steps of observation, generalization, and checking but are we correct in supposing that this simple sequence describes scientific method? To me it seems that the cited sequence has about as much relationship to scientific method as a few bones, say a tibia, a vertebra, and a jaw-bone, have to the whole animal. Scientific method is much more than a sequence of steps in problem solving and it is dangerous to suggest that it is merely the well-known sequence. It is possible to find instances where the sequence has been violated, or more often, where the sequence cannot even be detected.

We must not overlook the many little things which result in scientific progress—the faith in orderliness of nature, the use of analogy, the use of mathematical devices, the role of chance, the role of the intellectual climate, the motivating drives, the application of common sense, the failure to be guided by common sense. Thus, if we wrap scientific method up into a neat little package we are deceiving not only our students but ourselves.

How then, if we don't understand it, can we teach scientific method? The problem is not utterly hopeless for we can utilize two approaches which will make experience with the scientific method a part of the student's development. Student experience with scientific method can best be gained: (1) by observing and manipulating nature (the laboratory approach), and (2) by examining the observations and manipulations of original investigators (the historical approach). Both of these approaches are easily adapted to use with a wide variety of subject matter and at various student levels.

The historical approach to science instruction is merely sound teaching since it enables the student to see knowledge of the subject revealed in the manner in which it unfolded before the eyes of the greatest investigators in the field. Chemistry, for example, did not start out with a structural atom as some of our present-day textbooks do. The structural atom is a development of the past half-century and could not have been satisfactorily conceived before that time. It was necessary that there be developed first the concept of the

[2] *Yale Review*, 34, 444, 1945.

element, the relation between elements and compounds leading to the laws of chemical combination, the indivisible atom, atomic weights, valence, and the electrical behavior of chemicals. Only when these matters were understood was there a place and need for the structural atom. The greatest chemists of Europe could not have conceived the structural atom before the preliminary background was laid.

Realizing this, we still go ahead and introduce the structural atom into the course as early as possible. The student is delighted with the orderly logic of atomic structure (Of course he is not taken beyond atomic number twenty!) and finds the subject a fascinating mental exercise—like mathematics. However, he soon begins to flounder for lack of any practical acquaintance with elements and compounds and their reactions, and atomic structure begins to seem a sterile mental exercise. The concept would take on much greater significance had it been introduced after chemical combination had become meaningful. We expect the student to by-pass those essentials that the practicing chemists had to master before they could proceed. It would seem that the student can most easily master the subject in the manner that it was mastered by the best investigators in the field.

Historical material also helps to show that science is part of the human enterprise. This point is often missed when the course becomes solidly loaded with factual and theoretical material. In the past few decades science teachers have eliminated more and more historical material from their courses. This trend has been particularly marked in the colleges but has also taken place in the schools. The excuse has been that science progresses so the old must give way to the new. The fear of not being up-to-date is an awesome one for textbook writers.

This attitude is a dangerous one. It easily leads to the belief that only the new is important. However, the new often represents a development in applied science and leads to the belief that investigations, to be significant, must be practical. There is a failure to recognize that new developments have an earlier and more fundamental background. This recognition is more important than an aura of up-to-dateness.

It is less important for our students to know the name of the most recently successful antibiotic than it is for them to understand the background of investigations leading up to the development of successful antibiotics. It is more important to understand the germ theory of disease than to know the formulas of aspirin, sulfanilamide, and penicillin G.

The modernist will no doubt agree but will insist that one cannot waste time examining the development of the germ theory. One must

merely know the germ theory without understanding the reasons for the concept. In opposition to this argument one can maintain that this alleged waste of time in examining the development of the theory can be made the most meaningful aspect of the study. The student who has become familiar with the explorations of Pasteur, Lister, Koch, and Ehrlich will not only have gained a genuine understanding of germ theory but will have seen the unfolding of scientific knowledge through the activities of leaders in the field. Through the study of the work and thought of such pioneers the application of scientific method can be developed. Most important, it will not be an idealized scientific search for answers but one revealing mistakes, wrong ideas, and false motions more often than successes. Even the greatest investigators were only human beings. Their successes may have been due to superior training, greater intellect, unusual perseverance, better facilities, or sheer luck. This kind of examination of scientific activity is necessary if the student is to learn how scientists work and think. Without this kind of experience it is not possible to understand the real nature of the scientific enterprise.

If it is granted that the historical approach to the teaching of scientific methods is a desirable one there still remains the problem of how historical materials should be introduced. Several alternatives suggest themselves.

A random use of history is possible but is not apt to be very successful. The reasons are undoubtedly evident.

A second possibility is the history of science approach. The study of the history of science has finally become a respectable academic discipline, not only in Europe but in America. Harvard, Cornell and Wisconsin have led in the establishment of undergraduate as well as graduate study in the field. Should the schools also introduce the subject? The answer should clearly be negative. In order to fruitfully study the history of science the student must have a background of science. We must first teach science, including history, rather than history of science.

The third possibility, and the most useful one, is the case history. This approach has had a certain amount of use in the past but has received special attention in the last few years. Dr. James B. Conant and his colleagues have been emphasizing the values inherent in this approach and have pioneered in the development and use of case histories at Harvard.

The idea centers around the intensive study of a small number of important scientific developments, such as planetary motion, the dispersion of light, the pressure-volume relations in gases, the overthrow of the phlogiston theory, the atomic theory, molecular architecture, fermentation, photosynthesis, electromagnetic induction.

The sequence of observations and interpretations in the investigation of a scientific problem is studied in its intellectual and cultural framework. In this way it is possible to see the interplay of ideas, the groping, the false starts, the role of chance, the role of the working hypothesis, the influence of apparatus, the role of mathematics, the friction as well as the cooperation between personalities, the use of analogies, the influence of earlier concepts, the influence of the social, political, and religious climates.

As an illustration of the use of a case history we might dwell momentarily on the discovery of the rare gases. It may be recalled that in 1893 Lord Rayleigh (John William Strutt) reported that the density of nitrogen prepared from the air by removing other constituents was greater than for nitrogen prepared by the decomposition of nitrogen compounds. The discrepancy was not large but did suggest an anomaly. Several explanations (working hypotheses) were explored. The nitrogen from the atmosphere might be contaminated with oxygen, the "chemical" nitrogen might contain hydrogen, there might be an allotrope of nitrogen just as ozone was an allotrope of oxygen, or the atmospheric nitrogen might contain an inert gas of greater density than nitrogen. The latter explanation proved to be the only one to stand the test of experimentation when argon was isolated, to be followed in the next few years by helium, neon, krypton, and xenon.

The case illustrates numerous points of importance in scientific research. There is first the observation of an anomaly followed by the search for an explanation. Anomalies are common in science and they often lead to entirely new knowledge. On the other hand, they are often dismissed as insignificant errors, or matters not worthy of a busy man's time. If pursued they may open up an entirely new frontier in science, or they may result in an unresolvable dead-end.

It is of interest to note that the rare gases had been isolated more than a century before in some experiments which Cavendish made on air. Cavendish was also a careful and shrewd investigator. Why did he not recognize argon and the associated gases? This question relates directly to the importance of the times. The state of chemical knowledge in Cavendish's time was not developed to the point where the recognition of these gases was possible. Even if Cavendish had recognized the gas as unique he could not have made a separation or identification. Identification was based on use of the spectroscope, then a non-existent instrument. Separation was best made by liquefaction of the gas mixture, followed by fractional distillation. The liquefaction of such gases was developed just in time to aid the studies of Rayleigh and his associates.

The problem of where argon belonged in the periodic table was a

puzzle until it became evident that there was a whole family of chemically inert gases which required a completely new column in the table. This illustrates the effect of a new discovery on existing systems. The discovery of argon momentarily threw doubt upon: (1) the elemental nature of argon, (2) the validity of the periodic table. There was no spot in the existing table for an element with an atomic weight similar to that of potassium. The dilemma was made worse with the discovery of helium and was only resolved when the existence of additional inert elements suggested the need of a whole new column in the table.

The discovery of argon posed an atomic weight problem since no compounds could be formed. Equivalent weights determined by analysis of compounds had been a fundamental approach to the estimation of atomic weights. This avenue was closed. It was necessary to resort to other devices. Again, the progress in the study of gases was sufficiently advanced to permit the use of specific heat relations to solve the problem. The relation of specific heat at constant pressure and at constant volume had been studied for known gases and could be used as a means of estimating molecular size. The argon molecule proved to be monatomic and therefore the atomic and molecular weight were identical. Here we see the dependence on earlier research in a seemingly unrelated field.

It is of interest to see the interplay of investigations. Helium was isolated and identified by Rayleigh and William Ramsay after the discovery of argon. It was prepared by heating a uranium mineral which the American, Hillebrand, had shown to give off an unreactive gas which Hillebrand assumed to be nitrogen but which Ramsay suspected to be argon. It was spectroscopically identified as helium, a solar element whose spectral line had first been observed in 1868.

This by no means exhausts the lessons in scientific investigations to be learned from this case but it gives an indication of how the case may be used in the study of scientific method. It indicates a more stimulating learning experience than one which merely requires the students to master a few properties and uses of these strange elements. The case shows that scientific investigation is a complex phenomenon. It shows that progress is based upon earlier knowledge but that earlier knowledge can also be misleading. It shows scientists proceeding by "hunches" called "working hypotheses." Most important of all it reveals the difference between "facts" which are reproducible and often measurable and "concepts" (hypotheses, theories) which are the result of mental processes and which may be useful in scientific investigation without being true! In this way the relativity of truth becomes more apparent and more meaningful..

It is to be admitted that case histories satisfactory for college use

may not be satisfactory in the schools. The difference in level of student abilities is different but I see no reason why case histories cannot be adapted and successfully used at the school level. Cases can be simplified but still used to bring out important points.

There is also the question of time. Teaching science by the case history approach requires a more leisurely pace than is followed in many courses. The more intensive study of certain developments is going to require the deletion of other areas of subject matter. I wonder if this is not actually a gain. The greater interest and understanding in those subjects studied carefully should more than compensate for the loss in coverage.

It is of course true that not all subjects lend themselves to the historical treatment and there is nothing to be gained by forcing them into a case history. There is no reason why one's whole course should be a series of case histories. We might better use whatever approaches lend themselves to student understanding. In some areas this can be fruitfully done by the historical approach and in these areas the approach ought to be used.

There is finally the problem of source materials for the historical approach. Unfortunately the situation is not a happy one. A few case studies have been prepared for use at the college level but I am aware of nothing at the high school level. Consequently anyone using historical material will have to search for it and adapt it to the needs of his course. In order to be helpful I have gathered together a list of references. Copies may be obtained by writing to me at the Chemistry Department.

TAX FOR EDUCATION

"The American people are doing more than they have ever done before for the education of our Nation's children," Lee M. Thurston, Commissioner of Education, U. S. Department of Health, Education, and Welfare, said today.

"They are more actively working individually and organizationally for better schools and improved educational programs. They are taxing themselves to provide record numbers of school buildings and to help raise the salary level of qualified teachers. They are planning for the months and years ahead when all-time high enrollments will present new problems in most communities," the Commissioner said.

"Our citizens taxed themselves approximately 500 million dollars more last year than the year before to provide for their schools," said the U. S. Commissioner of Education. They spent about 7½ billion dollars during the year to operate public elementary and secondary schools and to put up new buildings. Figures furnished by the National Education Association show that the American people helped improve the average salary of the classroom teacher from about $3,240 to $3,400.

"American communities last year built approximately 50,000 new classrooms," Commissioner Thurston revealed. "The year before they built about 47,000. These were new records. This year we may expect another construction record of about 50,000 additional classrooms.

INTEGRATION IN THE TEACHING OF TRIGONOMETRY IN THE SECONDARY SCHOOL

T. E. RINE
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Success or failure in teaching at any level or in any area, in its final analysis, depends upon how well the pre-conceived purposes have been fulfilled. The poet says "work without hope draws nectar in a sieve, and hope without an object cannot live." Purpose and hope for its attainment must exist, else teaching and learning become futile. If this is a necessary condition, what then is the purpose of this discourse? It is the hope of the writer to point out the need for integration of subject matter in the teaching of trigonometry in the secondary school and to make a few suggestions as to how this might be done.

First of all let us consider a fundamental assumption. Fawcett says:

> "A unified program exists only when it exists in the mind of the student and the values associated with such a program are realized only when the inherent unity is recognized by the student. To achieve this desirable purpose it is not only essential that teachers understand the nature of the relationships between the different fields of experience but it is also necessary that the activities of the classroom be so planned that the student becomes increasingly conscious of a continuing and persistent emphasis on common general objectives."[1]

To achieve integration of the subject matter of trigonometry or in any area of mathematics in the mind of the student is not an easy task. This is especially recognizable when we realize that mathematics did not grow up inherently unified but developed, instead, like our good friend "Topsy." It is all the more important then that we should help the student to achieve this integration in his thinking. Then too, if we accept the generalization theory of transfer developed by Judd, trigonometry will have much greater functional values for the student if we help him to see it as a unified structure within itself and within the total realm of mathematics.

If the student is required to memorize hundreds of isolated ideas, trigonometry becomes tedious, dull, and boring to him. He usually then fails to see the forest because of the trees. In other words he fails to understand the broad general objectives. The student then visualizes mathematics not as a beautifully woven piece of cloth, but rather as a myriad of disconnected threads.

One of the purposes of teaching trigonometry in the secondary school, many writers agree, is to help the student to pull together and to maintain his previously developed concepts. The concepts de-

[1] Harold P. Fawcett, "A Unified and Continuous Program in Mathematics," *Bulletin of Illinois Council of Teachers of Mathematics*, 1949.

veloped in elementary algebra, plane geometry, advanced algebra, and solid geometry should all appear frequently in a course in trigonometry. Many writers agree, too, that trigonometry, because of its unifying principles, makes a fine point of termination of secondary school mathematics for both those who do and those who do not plan to go on to college. To teach trigonometry then from the purely mensurational point of view would miss the boat completely in this respect. Much time should be spent with problems involving measurement, of course, in the early stages, but I believe more time should be spent with problems that are continually pulling together the broad generalizations previously developed. Many of us are not without guilt in teaching trigonometry in a very piecemeal manner. Cannot trigonometry be taught in such a way as to help the student to see the various parts closely interrelated? Of course it can.

How then can this integration in the teaching of trigonometry be obtained? Let us consider first the introduction of the definitions of

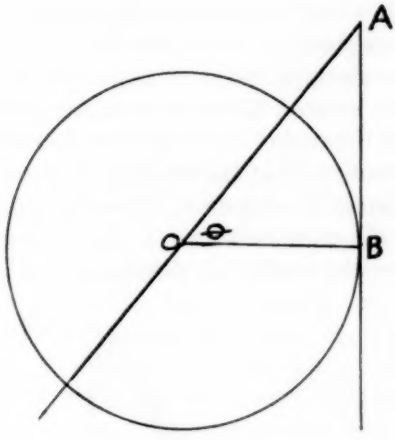

FIG. 1

the fundamental trigonometric functions. A student once asked his teacher if the word tangent as used in trigonometry has anything to do with the word tangent as used in plane geometry. The teacher quickly replied, "Forget it in connection with plane geometry and memorize the definition as given in the book." How sadly this teacher missed the boat in integration. A wonderful opportunity was given by means of which all the functions could have been developed. The student could have been helped in remembering these functions and he could have been helped in developing an integrated program of mathematics in his own thinking. Instead, a flame of disgust for mathematics in general and for trigonometry in particular was being

kindled. Yes, how fitting the axiom, "They learn what we teach, not what we think we teach."

Let's see how integration of subject matter could have been developed here. If we consider the historical development of the tangent function in trigonometry, we have a key to the answer. Consider a circle of unit radius. Draw a tangent at the extremity of a radius. Draw a secant through the center of the circle and intersecting the tangent as shown in fig. 1. What is the tangent of the angle θ formed at the center of the circle? How is it related to the definition learned by the student in geometry? Here there exists no conflict in the educative experience of the student. His future experience is enriched, not restricted. This could very well then be considered as an educative experience; not miseducation. The student's horizon has been broadened. He is beginning to see mathematics interrelated. In this same diagram what is the secant? Again the student has the answer from his experience in plane geometry. Then what about the cotangent and the cosecant? The student's previous experience from geometry provides the answer when the teacher helps him to recall the meaning of complementary angles.

What about the sine function? A historical development of the meaning of sinus as related to the half-chord provides the solution to the question and the cosine from the complement again follows. It is hoped at the same time that the student is developing some appreciation of the historical development of mathematics.

From this same diagram, as shown in fig. 2, several of the fundamental identities could easily be developed with the help of the

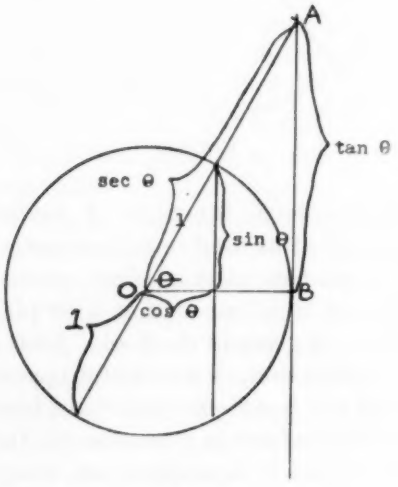

FIG. 2

Pythagorean theorem. From this diagram the student can readily recognize:

$$1+\tan^2\theta=\sec^2\theta$$

$$\sin^2\theta+\cos^2\theta=1.$$

Then too, from his knowledge of similar triangles in geometry, the student will readily recognize

$$\frac{\sin\theta}{\cos\theta}=\tan\theta.$$

Here the student begins to see a variety of interrelationships in mathematics—not isolated compartments of ideas totally apart from one another. A conscientious attempt to help a student to answer his own questions in the light of broad generalizations will help him to obtain an enriched and more meaningful conception of mathematics.

From the ideas of graphical work of algebra, the definitions can readily be extended by their relationship to the coordinate axes and thus the general definitions developed for the functions of the general angle. Failure to make this extension means missing the boat in an important tie-up between algebra and trigonometry as well as in extending the meaning of general angle.

What about the inverse functions? How many students go through a course in trigonometry without seeing the connection between inverse functions in trigonometry and the study of the dependent and the independent variables in algebra? This highly important concept of function and why the inverse function is so named should be developed with care. If this is done carefully the terms explicit and implicit functions of the calculus will have greater and deeper meaning to the student. A discussion of the graphical representation of $y=\sin x$ as compared to $x=\arcsin y$ is of importance. The student should be led to recognize that this interchange of dependent and independent variable has the same effect as 90° of rotation and 180° of reflection or 180° of rotation about the line $x=y$. This will help the student to deepen his understanding of inverse functions.

What about the work with identities? Here a sense of organic relationship regarding the whole group of formulas can and should be developed. Starting with a geometric development of the sine of the sum of two angles, the $\sin(A-B)$, $\cos(A\pm B)$, $\tan(A\pm B)$, $\sin 2A$, $\cos 2A$, $\tan 2A$, $\sin A/2$, $\cos A/2$, $\tan A/2$, or, in general, the functions of kA, where k is any positive integer, can all be developed from the first one algebraically. Thus the student can be led to see a beautiful integrated structure in this framework of identities.

In the study of identities the main distinction between an identity

and a conditional equation is not always pointed out to the student. Consider, for instance, (1) $\tan A = -\tan A$. Squaring each member gives (2) $\tan^2 A = \tan^2 A$. The immature student will perhaps say (1) then is an identity, since the right member in (2) has become the same as the left member. Only too frequently the teacher does not attempt to explain to the student that making the right member equal to the left member does not necessarily verify that the original expression is an identity. Here an algebraic discussion of conditional equations and identities can be very helpful in clarifying this situation.

To solve problems of a purely mensurational nature does not give the student the opportunity he needs to integrate his work in mathematics. Problems can be so chosen that the student will, of necessity, apply not only the definitions of functions, but also much of his previous work in mathematics, as well as many of the other fundamental relationships within the realm of trigonometry, itself. Let us consider, for instance, this problem. Referring to fig. 3, two points, A and B, are 1000 rods apart. Point C lies on a line intersecting AB

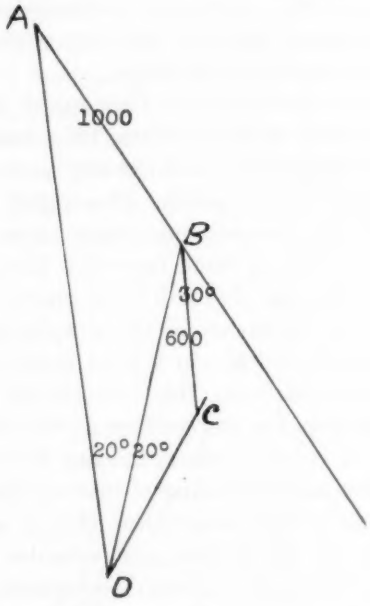

FIG. 3

at 30° and 600 rods from B. Point O lies in a position such that angle COB equals angle BOA equals 20°. Find OA, OB, and OC. If we study a solution of this problem we see, at once, the utilization of much of the student's previous mathematical experience. Angle $ABC = 150°$, angle $COA = 40°$, and hence angle $C = (170° - A)$. By applying the

sine theorem we obtain:

$$(1)\quad \frac{\sin 20^\circ}{\sin A}=\frac{1000}{OB} \qquad \text{and} \qquad (2)\quad \frac{\sin 20^\circ}{\sin (170^\circ-A)}=\frac{600}{OB}.$$

This gives us two equations in two unknowns which enables us to solve for OB. OA and OC can then easily be found.

What about the inclusion of complex numbers in a course in trigonometry? The concept of number should be extended in every course of mathematics if it is possible. The proof of DeMoivre's theorem: $(\cos \theta+i \sin \theta)^n=\cos n\theta+i \sin n\theta$, at least for positive integers can be used to illustrate proof by mathematical inducation without too great difficulty. Since this method of proof is usually not experienced very frequently by the secondary school student, a taste of it here would not be out of place. By means of DeMoivre's theorem along with the aid of the simple but remarkable idea that in the relation $a+bi=x+yi$, $a=x$ and $b=y$, the student can readily find $\sin n\theta$ and $\cos n\theta$.

Another suggestion in integration lies in the solution of the general triangle. Here a recall of 'when is a triangle determined?' is of much importance. Many students in present secondary school courses in trigonometry will begin their computational work without first considering the possibilities of solution from the given facts of the problem. Here is a wonderful opportunity for integrating the work of plane geometry with the work in trigonometry.

These are just a few suggestions as to how integration might be attained in trigonometry within itself and how the total mathematical experiences of the secondary school student can also be unified, at least to some extent. Helping the student to attain this integration in trigonometry has many implications in other areas of mathematics. If the teacher is conscientiously attempting to aid the student in this achievement, mathematics becomes not a study of many isolated parts, but a science of relationships and interrelationships. It becomes what it is supposed to be—deductive reasoning based on fundamental assumptions. This, perhaps, suggests that our traditional sequence of mathematics courses in the secondary school should be named Mathematics I, II, III, and IV instead of the way they are named at present. The titles of the traditional courses appear to imply disunity rather than unity. Only too frequently secondary school students raise the question: "Can we use our algebra in our work in geometry?" Let us encourage the student to develop power in mathematics by constantly helping him in the integration of the subject matter of mathematics. As in a nation, in union there is strength.

COLOR SLIDES OF THE PERIODIC CHART

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Presenting the Periodic Chart to the students in General Chemistry is always a pleasure and a satisfaction to the instructor. The student is elated to see a correlation and an element of order coming out of a maze of apparently unrelated experimental facts, and the teacher feels an added tone of cooperation from the class as the students are initiated to this system of classification.

One commercially available chart[1] now in wide use contains much more useful data than most students realize. Of necessity, this secondary information cannot be as boldly displayed on the chart as are the atomic symbol, number, and weight, and because of this it is difficult for students in a large class to see as many details as the instructor might like. The instructor who wants to go beyond a simple explanation of the basic organization of the periodic table and to take fullest advantage of the chart has therefore been handicapped.

Recently, the publisher of this chart has issued a set of 2×2-inch color slides, one for each element, which greatly facilitates detailed explanation and, in addition, offers a means of introducing some variety and perhaps some improvement in the methods of presenting the periodic table.

The brilliant colors projected on the screen compel attention and the details pertaining to each element are shown with complete clarity on the greatly enlarged image. Students who have seen the chart on the wall many times are astonished to learn after seeing the slides how much more information it provides than they had realized. A few minutes spent with the slides have been found to arouse additional interest in the periodic system, as evidenced by the increasing number of students who stop to study the chart.

The choice of slides to be used and the extent to which they can be discussed will depend upon the knowledge of chemistry already acquired by the students. Some of the more enthusiastic students have frequently asked, "Why don't you start the course with an immediate discussion of the periodic table?" This is not surprising, since some of our colleagues have said that they would like to start their general chemistry courses in just this way. We believe that an introductory discussion of the Periodic Table should be presented early in beginning courses in chemistry, but believe some experimental facts must be gathered together for the student before he can appreciate the value of the classification. This thought suggested

[1] Published by the W. M. Welch Scientific Co., Chicago.

that several different groups of a few selected slides might be shown to advantage at appropriate stages in the course.

The introductory use of slides has been made early in the course but limited to just a few elements. We have found that the initial presentation of the chart using the first three periods and the eight groups has been most successful in selling the students the principle and the utility of the chart. The simultaneous use of the corresponding color slides of these key elements seems to have made this approach even more successful. Electronic configurations of a few of the atoms were drawn on the blackboard and then the colored slides were thrown on the screen and some of the details explained; not all the information charted on the slide was explained but such valuable information as atomic number, atomic weight, electronic configuration and valence numbers was called to the attention of the student. Group I and Group VII were shown through Caesium and Astatine respectively, while the inert gases were carried through Radon as shown in Figure I.

H							He
Li	Be	B	C	N	O	F	Ne
Na	Mg	Al	Si	P	S	Cl	A
K						Br	Kr
Rb						I	Xe
Cs						At	Rn

FIG. 1

The transition from strongly electro-positive elements in the alkali family to the highly electro-negative character of the halogens is easily illustrated. The value of atomic number replacement over Mendeleef's atomic weight distribution can be shown using the slides of potassium and argon and showing their positions on the chart. The placement of potassium always precipitates questions and helps the instructor to explain the value of the chart as a research stimulant and a probe for more accurate atomic weight determinations.

In elementary organic chemistry, a rapid refresher summary of the chart is given during the second or third lecture of the course. An effective review may be rapidly given by making use of the same set of slides in the first and second period of the chart. Emphasis is placed on the slide of the carbon atom to show the unique position of the carbon atom and the known number of hydrides of the elements in this period as shown in Figure 2. Carbon's most striking property of sharing electrons with other carbon atoms to form long chain compounds is quite apparent, and catenation is no longer a sophomore mystery. If this chain formation is accepted, the plausibility of over half a million known organic compounds seems logical and another organic enthusiast has been born.

Number of Hydrides of the Period 2 Elements

Element	Li	Be	B	C	N	O	F	He
No. of Known Hydrides	1	0	6	about 3,000	3	2	1	0

FIG. 2

A third use of this same set of key slides mentioned in Fig. 1 may be exemplified in a later discussion of the alkali metals. Here the slides are projected as the chemistry of these elements is discussed. The electronic configurations and chemical properties are pointed out as the atoms increase in atomic number from Li to Cs in this slide group.

A fourth use of this same set of slides is obvious in the halogen series of the elements from F to At. Their electron configurations series of the elements from F to At. Their electron and configurations and chemical and physical properties may be effectively reemphasized by showing the slides of these elements during the appropriate lecture on the Halogens.

Near the end of the freshman course we have found the use of the slides of the transuranium elements very effective in presenting atomic energy and the atom bomb. The slides of Uranium, Neptunium, Plutonium, Americium, Curium, Berkelium, and Californium, add interest to this fascinating portion of the periodic chart.

We have found these color slides a useful aid in presenting the periodic chart to students in general chemistry; the students begin to use the chart to fuller advantage and seem to understand the frequent use the instructor makes of the chart during lecture periods. An objection occasionally made to the use of any slides or films in the classroom is that the student has no means by which he can refresh his memory concerning what he has seen. In the present case, the wall chart is permanently displayed where it is always available for reference. Being identical in arrangement and color to the slides, it becomes a frequent reminder of the material shown on the screen. The above mentioned objections to slides therefore seems to be well answered in this instance.

There has been widespread criticism that too few students can correctly classify the principal elements after completing the usual course in General Chemistry.[2] In one case,[3] it was found that over half of the undergraduates and one-third of the graduate students were unable to place as many as ten elements correctly. Perhaps the added interest aroused by the use of this new visual aid will help correct this situation.

[2] Herbert C. Brown and Charles L. Rulfs, *J. Chem. Educ.*, 27: 437 (1950).
[3] Fred Basolo, *J. Chem. Educ.*, 28: 285 (1951).

BISULFITE WOOD PULPING

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Industrial by-products are frequently very annoying to residents in the neighborhood of the plant. The copper smelters of Montana, a number of years ago, were induced by complaints of alfalfa farmers, reinforced by an investigation of a trained plant physiologist, to add a Cottrell precipitator to their smoking chimneys. In the end the sulfur dioxide gas salvaged produced more than enough sulfuric acid to pay for the installation and its operation. Similarly pulp mills of the northwest are learning to decrease stream pollution and increase their income by burning rather than dumping pulping sulfite liquors.

"One of the serious difficulties of the sulfite process," says N. K. Benson,[2] "is the disposal of the waste sulfite liquor from the pulp mill. Approximately one-half of the wood goes into the solution and together with all the lime used in the mill and most of the sulfite, must be discharged into some sort of drainage channel. . . . (Its high oxygen demand is) its first effect. . . . (This exhaustion) of the supply of oxygen dissolved in the water . . . (causes) the death of fish and other aquatic life. . . . So serious has this become in some places . . . (that the) mills have been compelled to shut down."

The sulfite process, referred to above, is used "in the manufacture of sulfite pulp. . . . (It uses) sulfur from the Gulf district (which) is burned in a rotary burner (to make) . . . sulfur dioxide. This dioxide is cooled and passed over lime stone in towers, countercurrent to descending liquid. This yields a solution of bisulfite of lime ($Ca(HSO_3)_2$) containing free sulfurous acid (H_2SO_3) and constitutes the cooking liquor" that dissolves out the lignin from the wood chips. The desired cellulose residue is called the pulp.

When the waste liquors from pulping could be discharged directly into the ocean or into arms of the sea dilution was attained quickly so that little damage was done. As the mills moved inland, however, and became dependent upon rivers for removal of the waste liquors another industry of the northwest became vocal. The fishermen made effective protest.

As a result the pulp and fiber factories of the northwest have increasingly adopted the "combustion method" of waste liquor disposal instead of "dumping." Since about half of the chips for pulping is found in that liquor after cooking it is apparent that this waste liquor has a considerable tonnage of burnable fuel.

[1] Professor Emeritus, Department of Chemistry, University of Nebraska, Lincoln, Neb.

[2] Benson, Henry K., "Pulp and Paper Industry of the Northwest." Bulletin Number 1, Page 9. University of Washington, Seattle. 1929.

Research further improved the job done by the burning unit. By substituting magnesium hydroxide for lime in making the bisulfite solvent the "burning" produced useful products. Magnesium bisulfite decomposes more completely into the metal's oxide, water and sulfur dioxide than does the analogous calcium bisulfite under the same conditions. Thus, not only is the polluting bisulfite not dumped but the oxides of magnesium and of sulfur are salvaged for re-use in making solvent liquor for more chips. Present practice[3] thus recaptures from 78 to 82 per cent of the original sulfite.

In preparing the liquors for successful burning they are, by evaporation, concentrated from a 12 to a 60 per cent solid content. This concentrate is sprayed into recovery boilers where the burning takes place. In order to prevent the oxidation of any considerable portion of the magnesium bisulfite to magnesium sulfate the air fed to the recovery boiler must be kept at a relatively low percentage. This restricted air supply, however, tends to leave unburned carbon in the magnesium ash. This is not desired. Thus, from an engineering point of view, this control of air supply is the most critical factor in the process's operation. However, "it is believed that a new recovery unit could be designed which would recover as much as 85 to 90 per cent of the chemicals."[4]

Chemical recovery efficiency is not the sole criterion of the success of the combustion method of waste disposal . "(This) process has two very important advantages over a calcium base system in addition to the recovery of cooking chemicals. Approximately 10,000 pounds of steam are produced by burning the red (waste) liquor for each ton of pulp produced."[5] Seventy per cent of the heat power thus produced is available in other parts of the mill. "The other important advantage is . . . (the waste is burned and not dumped into the streams as a pollution)."

Since there is, in current practice, a loss of about 20 per cent of the sulfite its continuous replacement is needed. The sulfur dioxide for this replacement is made by burning Gulf sulfur. The magnesium base, however, is obtained from dolomite, a rock similar to limestone, and purified sea water. The sea water contains magnesium chloride in solution. After the dolomite is burned (decomposed) in a kiln the resulting calcium and magnesium oxides are mixed with the sea water. The magnesium chloride of the sea water reacts with the calcium oxide of the dolomite residue to form calcium chloride and magnesium hydroxide. The hydroxide is separated from the water by rotary filters. The hydroxide may be changed to magnesium oxide by heating to decomposition. In actual practice it is shipped in tank cars as

[3] Mill Reports. Weyerhaeuser Timber Co., Nov. 7, 1952.
[4] Mill Reports, *loc. cit.*
[5] Mill Reports, *loc. cit.*, page 2.

hydroxide slurry. The slurry is easier to handle than the dry magnesium oxide.

The pulping industry has decreased the waste in wood processing by converting saw dust into marketable products rather than consuming it as a cheap fuel. There is still the possibility of a further conservation. The chief ingredient of the waste from pulping is lignin. "Next to cellulose lignin is the most abundant chemical component of plants. Coniferous woods contain as much as twenty-four to twenty-eight per cent. The amount of lignin burned or wasted in the United States is equal, on a dry basis, to twice that of the non-ferrous metal production of the whole United States. This total does not at all represent the amount of lignin that could be made available if sufficient extensive and valuable uses could be found for it."[6] This is a biproduct of the pulping. It is an abundant chemical awaiting efficient separation from its solvent. It also needs a lift from the ranks of the unemployed.

[6] Magazine *Wood*, page 54. 139 North Clark St., Chicago. Nov. 1951.

THE READING CLINIC

The Temple University Tenth Annual Reading Institute was held in Philadelphia during the week of February 2 to 6, 1953. The delegates who attended this week's program of meetings for classroom teachers, school administrators, psychologists, and vision and reading specialists represented thirty-five states, Canada, and Norway. This group comprised one of the largest every to attend these annual conferences.

Throughout this year's sessions, the emphasis was placed upon basic considerations in the organization of effective reading programs for the development of reading skills in all areas of instruction at every school level. The conference was under the direction of Dr. Emmett A. Betts, The Temple University Clinic Staff, and such visiting lecturers as Dr. Israel Dvorine, Baltimore; Dr. Daniel Prescott, University of Maryland; Dr. William Sheldon, Syracuse University; and Dr. Paul Witty, Northwestern University. Under the guidance of these specialists, conferees were trained in practical classroom techniques for the teaching of reading and the correction of reading difficulties. Laboratory sessions were provided to give delegates an opportunity to practice certain of these techniques under the supervision of trained specialists.

Perhaps the most significant single meeting during the week's program was the outstanding address delivered by Dr. Paul Witty at the Thursday evening banquet sponsored by the Temple University Chapter of Phi Delta Kappa. Dr. Witty discussed "Some Characteristics of a Balanced Reading Program" and emphasized the need for inclusion in a developmental reading program specific attention to the development of interests in and tastes for a wide range of children's literature. He pointed out the value of developing, in those who are preparing to teach, a love of literature that might be transmitted to the children whom they would be meeting in their classrooms.

The Temple University Reading Clinic has announced that *Differentiated Guidance* will be the theme for the 1954 Institute Program. This session is scheduled for the week of January 25–29, 1954. A copy of the complete program will be available in November of this year. Those interested in securing advance information about the 1954 Program should write to Dr. Emmett A. Betts, The Reading Clinic, Temple University, Philadelphia 22, Pennsylvania.

FISH STORY

ORVILLE F. WARNING
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Experience with me an imaginary trip. Taking leave of our natural habitat on the surface of the earth, come with me under water to the bottom of the water ocean. Neglecting such trivial matters as to how we shall breathe or carry out other life activities, let us visit with students in the world of water instead of air.

While down here at the bottom of the ocean, the first personage I meet is a fish. Upon conversing with him, I am surprised to find that he is a physics student in a physics class similar to the one in which I teach. Being a stranger from the world of air, I strike up a conversation with him concerning his environment.

"As I observe you fish complacently swimming about down here in this ocean of water, I often wonder if you fish are aware of the terrific pressure of water bearing down upon you at all times?"

"Pressure? What pressure?" replied the somewhat surprised fish holding out a fin in an exploratory manner as if to see if he could feel any such pressure. "I don't feel any pressure!"

"But don't you even realize that you are swimming around in this fluid that is all around you?" I replied, wondering how they could possibly miss what to me was perfectly obvious.

"I can move around and about with no apparent difficulty at all. Do you mean to tell me that this hydrosphere I swim in really is something? I can't feel it or even see it. One can only imagine that which one cannot see. When I swim fast I can feel something brushing past me, or when the current blows, it sometimes flips sand up into my face or blows me to one side, but other than that I am not bothered at all. I cannot even imagine this water you speak of as being even visible let alone exerting pressure."

"But haven't you been studying about pressure in physics class? You surely must realize that this fluid all around you exerts pressure!"

"Now that you mention it," thoughtfully replied the fish, "our instructor did talk about a fluid around us that exerts pressure, but we fish students didn't quite understand it. I have some numbers jotted down here in my notebook for the next physics test, let me see. Oh, yes, here it is—'the pressure in the fluid decreases by 62.4 pounds per square foot or about one-half pound per square inch for every foot increase in altitude.' I shall have to memorize that for the exam."

Poor fish. I guess a fish is the hardest person in the world to convince that he actually lives in the water, and that this fluid exerts

pressure on him. Perhaps if I recalled some familiar experiences to him, the presence of water and water pressure would become more meaningful to him. Continuing the conversation, I followed as he led me into the physics laboratory.

"I see an empty beaker over there on the lab table. It appears empty to you but it is really a full beaker as I see it."

Somewhat shocked at my remark, the fish picked up the beaker and turned it upside down as if pouring something out onto the desk top. "How can you say this beaker is full? Nothing pours out. Even this bottle with the narrow necked opening is empty as nothing pours out from it!"

He almost had me there until I noted a beaker of mercury on a nearby shelf. I brought the mercury over to the doubting fish and asked, "could you show me how one would fill this narrow necked bottle you said was empty?" I handed him the mercury and he attempted pouring the mercury into the bottle. As I suspected would happen, a little mercury entered the bottle and the rest spattered over the desk top. The fish apologized for being so careless and went to look for a funnel. The funnel nestled so tightly on the rim of the bottle that the funnel merely filled with mercury, little entering the bottle. "Ah, you see, the bottle isn't empty after all. The water already inside prevents the mercury from entering." The fish looked puzzled and then thought to lift the funnel a little from the neck of the bottle so that the water could escape. As the water blurped out, the mercury dropped in.

"Say, do you have an exhaust pump around here?" I asked as an inspiration for a good demonstration came to me.

"Do you mean a suction pump as we fish students call it? The teacher calls it a water pump but I can't see why. One can't see what is being pumped. All we notice is that things seem to get pulled into regions where this suction appears."

His remark strangely reminded me of comments I had heard from similar students up in the world of air, where they talked about things being pulled because of suction, so I would attempt ways to get this fish student thinking in terms of water pressure instead of suction as being responsible for pneumatic, or I guess they refer to them as hydromatic devices down here.

"You find a cork for this bottle. Run a glass tube with a stopcock through the cork and we will weight the whole works on this beam balance scale." While he prepared the cork with my assistance, I didn't have the heart to tell him that the weights for his beam balance scale were not correct as marked since they were being buoyed up by the weight of water they displaced. After all, students need confidence in some things, especially a scale balance that they

take for granted all the time as a precision tool. The fish completed the preparations and we proceeded to weigh the bottle. He did wear a frown upon his face when I casually remarked that we would first weigh the bottle full, and later weigh it when empty. We connected the glass tubing to the exhaust pump, and even I had difficulty visualizing the water being pumped out of the bottle, so accustomed had I become to my new surroundings.

Closing the stop-cock so that no fluid could rush back in, we again weighed the bottle and noted the loss in weight. To say that the fish was surprised would be putting it mildly. He immediately wanted to know exactly how much water was removed from the bottle. Putting the end of the glass tubing into the beaker of mercury and opening the stop-cock valve, a regular fountain or geyser of mercury poured into the bottle. Measuring this amount of mercury in a graduate, the equivalent volume of water was obtained. To the surprise of the fish, the water did have weight and its density could be measured. In fact, we calculated water as weighing 62.4 pounds per cubic foot or one gram per cubic centimeter.

Mr. Fish was very attentive and ready to listen to me now. Finding a piece of glass tubing bent into a U-shape, I held it with the open ends up. Student fish said the tube appeared to be empty, but didn't disagree too violently when I said it really was full of the fluid water that was all around us. I poured a little mercury into one of the arms of the U-tube. The fish was quite amused by alternately opening and closing the other end of the U-tube as I poured, noting that when his end was closed, the mercury started filling the open arm, but when opened, the mercury sought the same level in both arms of the tube.

I pointed out that when both arms were open, the same pressure of water above us would be exerted equally on both surfaces of the mercury. I asked the student fish to apply what he termed suction to one of the arms of the U-tube and he noted the rise of mercury in that arm of the tube. When I tried to explain that it really was water pressure on the open end that pushed the mercury up on the other side, he looked a little skeptical. However, he agreed that if we could only produce a perfect suction or what I called zero pressure in one arm of the tube that would be equivalent to the pressure at the very top of his water ocean, we perhaps could measure the actual pressure of water around us by the difference in height of the two mercury columns. So I asked him to procure a long piece of glass tubing sealed at one end.

In attempting to fill this tube with mercury, the fish remembered his past experience trying to fill the narrow necked bottle, so he made sure the water could flow out as the mercury was poured in.

After completely filling the tube, I carefully asked the student fish just what was in the tube.

"There's just mercury in the tube. Because of the impenetrability of matter, no two things can occupy the same space at the same time, so there must be only mercury in the tube," smugly replied the fish, obviously delighted with his knowledge.

"Are you sure there is nothing else in the tube?" I repeated for emphasis.

"No, there is nothing else in the tube that I can see, just mercury."

With that show of confidence, I placed my finger over the open end of the tube completely filled with mercury, turned it upside down, and removed my finger only after I was sure the open end was well immersed in the beaker of mercury that was handy. I smiled an inward smile as we both looked at the upper, closed end of the tube, for sure enough, the mercury had dropped away from the top so that an empty space could be clearly seen. A flood of questions came immediately.

"Why does the mercury not continue to fill the entire tube? What is in that space above the mercury? Why does it fall so there is only a certain height of mercury?"

I reminded him again that there was nothing else in the tube but mercury.

His eyes brightened. "Then if there is nothing, absolutely nothing in the tube above the mercury, that must be the zero pressure you were talking about that would be at the top of the water ocean so that we can now measure the actual water pressure all around us down here".

"That's it exactly," I replied with usual enthusiasm.

"Then all we have to do is measure the height of mercury and calculate its pressure, which will compare with the water pressure around us," excitedly responded the fish. He quickly measured the height of the mercury column. Paying no more attention to me, the fish feverishly thumbed through the tables in the back of his physics book to find the density of mercury as I quietly slipped out of the lab.

Realizing too that I was subject to this water pressure, I returned from the bottom of the water ocean to the bottom of our air ocean once again. Could it be as easy to convince the students in my own classroom that they likewise live at the bottom of an air ocean? Perhaps weighing air in the lab or observing a Torricelian tube could have more meaning.

Razor blade sharpener hones double-edged safety blades while they are in the razor, wiping, drying and oiling them at the same time. The device is said to help the user squeeze 30 shaves out of each blade.

SUGAR COATED PILLS OF SCIENCE

JEANNE L. GELBER AND EDITH S. HODGES
Baytown, Texas

A combination of events has created a serious shortage of chemists, engineers, and natural scientists. The nation is faced with a period of unusually low science enrollments at a time when industrial science is expanding at an unprecedented rate. It is the duty of every science teacher to encourage well-qualified young people to enter the field of science. But since all persons are not equipped mentally and temperamentally to become scientists, care must be exercised in encouraging unselected individuals to continue in this field of endeavor.

Because of the great loss in enrollment in high school before graduation, there is a growing revolt against teaching which lacks realism. The science teacher can make his subject positive, living, and exciting if he brings the subject out of the class room and presents it to the pupil in its proper relation to the contemporary world. Since experiences are more lasting when they develop vivid concepts, field trips provide adventures in industry which promote interest and enthusiasm both in the fun of planning and in participation.

In order to have whole-hearted fun and at the same time interest boys and girls in the field of science, tours—both long and short—may be planned by a science club. They are coordinated with the course of study and must be well organized in advance so that they may be successful and beneficial. In the spring a poll of the interests of the cocurricular group is taken to determine the field trips deemed desirable by the majority of the group. During the vacation, preschool sponsor-officer conferences are held to plan a tentative year's program. Knowing that activities mean committees and that comittees mean practice in cooperation, separate groups are set up to make plans for each trip.

The committee must feel that the success of the specified field trip depends upon them. They must learn how to secure permission from proper authorities for the visit and how to untangle the red tape involved in obtaining transportation for the club on school buses. At the club meeting preceding the excursion, a committee member indoctrinates the group in the ideal of conduct which will establish rapport between the club and its host. Shortly before time to leave, a member checks to be sure that the bus is at the designated place and gives the driver route instructions. Another's function is to see that the club photographer takes his camera and films to insure a pictorial record of the trip. A few days later, a letter of thanks is sent to the public relations officer of the place visited in the name of the organization.

Lessons and experiences gained from these carefully planned field trips may be summed up as follows:

1. Carefully advanced planning assures the success of the field trip.
2. Since science clubs are on a voluntary basis, the youth learn to work for the joy of working.
3. Courtesy through life is a by-product of the training received in cocurricular organizations.
4. Science clubs receive the cooperation of industry because American business is one of the "largest stockholders in education."
5. Field trips show students democracy at work in independent business enterprises.

Company Contacted	*Reaction Toward a Proposed Field Trip*
Monsanto Chemical Company Texas Division, Texas City	Expansion program of the corporation prohibits the use of employees as guides.
Ethyl Corporation Houston, Texas	Newness of plant prohibits field trips.
Sheffield Steel Houston, Texas	National emergency prevents the corporation from having visitors.
San Jacinto Ordnance Depot Channelview, Texas	Will plan tour any time convenient for the students.
J. M. Huber Corporation Elton, Texas	A trip can be taken by small groups, dressed in old clothes and shoes.
Planetarium, University of Houston, Houston, Texas	One and a half hour lecture and demonstration offered to students.
Freeport Sulphur Company Freeport, Texas	Permission given for trips on Tuesday, Wednesday and Thursday.
Champion Paper and Fiber Co. Houston, Texas	Two hour trip offered at the convenience of the club.
Humble Oil & Refining Co. Research Laboratory Glassblowing Laboratory General tour Physical Testing Laboratory	One hour trip to each place, arranged to suit the convenience of the club.
The Baytown Sun Baytown, Texas	One hour trip offered.
General Tire & Rubber Co. Baytown, Texas	The company will plan a two hour trip for the club.
Ice Plant Baytown, Texas	One hour trip offered.
Mutual Benefit Association Baytown, Texas	One hour lecture and hour demonstration.
San Jacinto Hospital Baytown, Texas	One hour tour planned by the business manager.
Water Purification Plant Baytown, Texas	One hour trip offered.
Fire Department Baytown, Texas	Will allow a visit from the club.
Southwestern Assoc. Tel. Co. Baytown, Texas	One hour tour, planned by the company.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

In general when several solutions are correct, the ones submitted in the best form will be used.

Late Solutions

2353, 4, 7. *Felix John, Phildaelphia.*

2354. *Lester Moskowitz, New York.*

2355. *C. W. Trigg.*

2359. *No solution has been offered.*

2360. *Proposed by Ophelia Warne, McDuffietown, N. Y.*

Solve:

$$\sqrt{x+9}+\sqrt{x^2-9}=\sqrt{34}+4\sqrt{34}+4$$

Solution by C. W. Trigg, Los Angeles City College

Should this have been

$$\sqrt{x^2+9}+\sqrt{x^2-9}=\sqrt{34}+4?$$

If so, then

$$x^2+9+2\sqrt{x^4-81}+x^2-9=50+8\sqrt{34}$$

$$\sqrt{x^4-81}=25+4\sqrt{34}-x^2$$

$$x^4-81=1169+200\sqrt{34}-2(25+4\sqrt{34})x^2+x^4$$

$$x^2=\frac{125+200\sqrt{34}}{50+8\sqrt{34}}=25$$

$$x=\pm 5.$$

Julian Braun, Washington, D. C. by numerical analyses solved this:

$$\sqrt{x+9}+\sqrt{x^2-9}=\sqrt{34}+4,$$

the solution being 27.29554 (approx.).

2361. *Proposed by Alice Yello, Yonkers, N. Y.*

Solve for x, y, z:

$$a^2(y+z)=xyz$$
$$b^2(x+z)=xyz$$
$$c^2(x+y)=xyz$$

Solution by Leon Bankoff, Los Angeles, Calif.

$$\frac{1}{a^2}=\frac{y+z}{yxz}=\frac{1}{xz}+\frac{1}{xy}$$
$$\frac{1}{b^2}=\frac{y+z}{xyz}=\frac{1}{y^2}+\frac{1}{xy}$$
$$\frac{1}{c^2}=\frac{x+y}{xyz}=\frac{1}{yz}+\frac{1}{xz}$$

So

$$\frac{1}{a^2}+\frac{1}{b^2}-\frac{1}{c^2}=\frac{2}{xy} \tag{1}$$
$$\frac{1}{b^2}+\frac{1}{c^2}-\frac{1}{a^2}=\frac{2}{y^2} \tag{2}$$
$$\frac{1}{a^2}+\frac{1}{c^2}-\frac{1}{b^2}=\frac{2}{xz} \tag{3}$$

Multiplying (1) and (3) and substituting the value of $2/yz$ from (2), we get

$$x=\sqrt{\frac{2a^2b^2c^2(a^2c^2+a^2b^2-b^2c^2)}{(b^2c^2+a^2c^2-a^2b^2)(b^2c^2+a^2b^2-a^2c^2)}}$$

Similarly,

$$y=\sqrt{\frac{2a^2b^2c^2(a^2b^2+b^2c^2-a^2c^2)}{(b^2c^2+a^2c^2-a^2b^2)(a^2b^2+a^2c^2-b^2c^2)}}$$
$$z=\sqrt{\frac{2a^2b^2c^2(b^2c^2+a^2c^2-a^2b^2)}{(a^2b^2+b^2c^2-a^2c^2)(a^2b^2+a^2c^2-b^2c^2)}}$$

Obviously, another solution is $x=y=z=0$.

Solutions were also offered by C. W. Trigg, Los Angeles; A. R. Haynes, Tacoma, Wash.; H. M. Feldman, St. Louis; Julian H. Braun, Washington, D. C.; Robin Eshneour, Waterloo, N. Y.; Mrs. W. R. Warne, Syracuse, N. Y.; Lester Moskowitz, New York; Felix John, Philadelphia.

2362. *Proposed by Dwight L. Foster, Florida A and M.*

If

$$y=\arctan\frac{\sqrt{1+x^2}+\sqrt{1-x^2}}{\sqrt{1+x^2}-\sqrt{1-x^2}}$$

show that $x^2=\sin 2y$

Solution by Dwight L. Foster

$$\tan y=\frac{\sqrt{1+x^2}+\sqrt{1-x^2}}{\sqrt{1+x^2}-\sqrt{1-x^2}}=\frac{1+\sqrt{1-x^4}}{x^2}$$

$$\therefore \quad x^4\tan^2 y-2x^2\tan y+\lambda=\lambda-x^4$$

$$\therefore \quad x^2(\tan^2 y+1)=2\tan y$$

whence

$$x^2=2\sin y\cos y=\sin 2y$$

Solutions were also offered by Leon Bankoff, Los Angeles, Julian H. Braun, Washington, D. C.: H. M. Feldman, St. Louis, Mo.; C. W. Trigg, Los Angeles,; Nathaniel Grossman, Aurora, Ill.; A. R. Haynes, Tacoma, Wash.; Richard H. Bates, Milford, N. Y.; Benjamin Birge, Amherst, Mass.; Mertie Benjamin, Appomattox, Va.; Felix John, Philadelphia.

2363. *Proposed by C. W. Trigg, Los Angeles City College*

If A, B, C, D, represent the areas of the faces of a tetrahedron, with M their sum and N the sum of their six products two at a time, show that

$$2N\leqq(3/4)M^2<3N. \tag{1}$$

Solution by H. M. Feldman, Beaumont High School, St. Louis

For any set of four quantities A, B, C, D, we have:

$$0\leqq\sum(A-B)^2=3\sum A^2-2\sum_{A\neq B}AB. \tag{2}$$

If we now add $6\sum AB$ to both sides of (2) we get:

$$8\sum AB\leqq 3\sum A^2+6\sum AB=3(\sum A)^2$$

or

$$2N\leqq(3/4)M^2. \tag{3}$$

Let us now assume that A, B, C, D, are in descending order of magnitude, and remembering that the areas of the faces of a tetrahedron must all be positive, and that none of these areas can be as large as the sum of the remaining three; we get the following inequalities:

$$A-B<C+D<A+B, \qquad C-D<C+D.$$

From these it follows readily that

$$(A-B)^2+(C-D)^2<2(A+B)(C+D)$$

or

$$\sum A^2<2\sum AB.$$

Adding $2\sum AB$ to both sides we then get

$$(\sum A)^2<4\sum AB \quad \text{or} \quad (3/4)M^2<3N. \tag{4}$$

Relations (3) and (4) are evidently equivalent to (1).

A solution was also offered by the proposer.

2364. *Proposed by B. B. Libby, San Francisco.*

Show that $\tan 3x\cot 2x$ cannot lie between $1/9$ and $3/2$

Solution by H. M. Feldman, St. Louis

Let $y=\tan 3x\cot 2x$. Then expressing y in terms of $\tan x$, we get,

$$\tan^4 x+2(3y-2)\tan^2 x+(3-2y)=0.$$

From this equation we obtain the roots

$$\tan^2 x = 2-3y \pm \sqrt{(2-3y)^2-(3-2y)} = 2-3y \pm \sqrt{(9y-1)(y-1)}.$$

From the last expression we see that y cannot lie between $1/9$ and 1 since that would make the radicand negative, while when y is between 1 and $3/2$ $2-3y<0$ and

$$|2-3y| > \sqrt{(2-3y)^2-(3-2y)},$$

which would make $\tan^2 x$ negative. This shows therefore, that the values of y in the interval

$$\tfrac{1}{9} < y < \tfrac{1}{2},$$

must be excluded.

Solutions were also offered by H. M. Feldman, St. Louis, Mo.; Charles Salkind, Brooklyn, New York; Julian H. Braun, Washington, D. C.; Peter Markstein, Brooklyn, New York; and the proposer; Lester Moskowitz, New York; C. W. Trigg, Los Angeles City College.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each high school contributor will receive a copy of the magazine in which the student's name appears.

For this issue the Honor Roll appears below.

PROBLEMS FOR SOLUTION

2377. *Proposed by Leon Bankhead, Los Angeles*

C is a point on AB, with $AC>CB$. With C as center quadrants BE and AD are described on the same side of AB. D and E are joined by semi-circle forming a *cusp* at D and a flex point at E. Show that the area enclosed by the Figure $ABEDA$ is equal to that of the semi-circle on AB.

2378. *Proposed by Leon Bankhead, Los Angeles*

AB is the common external tangent of two externally tangent circles. If AB remains fixed while the tangent circles vary, what is the locus of the center of the circle that is tangent to the two circles and to AB?

2379. *Proposed by Leon Bankhead, Los Angeles*

P is any point on semi-circle described externally on side BC of square $BDEC$. PD and PE cut BC in F and G respectively. Show that $BF.GC=FG^2$.

2380. *Proposed by Eugene D. Nichols, Urbana, Ill.*

Solve the system

$$x\left(\frac{y}{z}+\frac{z}{y}\right)=a$$

$$y\left(\frac{x}{z}+\frac{z}{x}\right)=b$$

$$z\left(\frac{x}{y}+\frac{y}{x}\right)=c$$

238.. *Proposed by C. W. Trigg, Los Angeles City College*

The sum of the n^{th} and the $(n+1)^{th}$ elements of the fourth row of the Pascal (arithmetic) triangle equals the sum of the squares of the first $n+1$ integers.

2382. *Proposed by W. R. Warne, Syracuse, N.Y.*

Solve with skill

$$\frac{3x-25}{3x-1}=\frac{3x+5-6\sqrt{3x}}{3x+2-3\sqrt{3x}}.$$

BOOKS AND PAMPHLETS RECEIVED

ENGINEERING STATISTICS AND QUALITY CONTROL, by Irving W. Burr, *Professor of Mathematics and Research Associate in the Statistical Laboratory, Purdue University.* Cloth. Pages xi+442. 14.5×23 cm. 1953. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y. Price $7.00.

MATHEMATICS AND STATISTICS FOR ECONOMISTS, by Gerhard Tintner, *Professor of Economics, Mathematics, and Statistics, Iowa State College.* Cloth. Pages xiv+363. 14.5×23 cm. 1953. Rinehart and Company, Inc., 232 Madison Avenue, New York 16, N. Y. Price $6.50.

A BRIEF SURVEY OF MODERN ALGEBRA, by Garrett Birkhoff, and Saunders MacLane, *Professors of Mathematics in Harvard University and the University of Chicago.* A Shorter Version of *A Survey of Modern Algebra, Revised Edition.* Cloth. Pages viii+276. 13.5×21 cm. 1953. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y. Price $4.75.

RELATIVITY AND REALITY, by E. G. Barter. Cloth. Pages xi+131. 13.5×21.5 cm. 1953. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $4.75.

A REFRESHER COURSE IN MATHEMATICS, by F. J. Camm, *Editor: Practical Engineering, and Practical Mechanics.* Cloth. 240 pages. 12×18.5 cm. 1953 Emerson Books, Inc., 251 West 19th Street, New York 11, N. Y. Price $2.95.

ALONG THE GREAT RIVERS, by Gordon Cooper. Cloth. 159 pages. 13.5×21.5 cm. 1953. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $4.75.

SQUARING THE CIRCLE, by E. W. Hobson; Ruler and Compass, by H. P. Hudson; The Theory and Construction of Non-Differential Functions, by A. N. Singh; How to Draw a Straight Line; A Lecture on Linkages, by A. B. Kempe. Cloth. Total Number of pages 311. 11.5×18 cm. 1953. Chelsea Publishing Company, P. O. Box 55, Washington Bridge Sta., New York 33, N. Y. Price $3.25.

AN INTRODUCTION TO SYMBOLIC LOGIC, by Susanne K. Langer. Second Edition Revised. Paper. 367 pages. 13. 20.5 cm. 1953. Dover Publications, Inc., 1780 Broadway, New York 19, N. Y. Price $1.60. Cloth $3.50.

HOW TO KNOW THE SPIDERS, by B. J. Kaston, *Professor of Biology, Teachers College of Connecticut,* and Elizabeth Kaston. *Spiral Bound.* Paper. Pages vi+220. 13.5×21.5 cm. 1953. Wm. C. Brown Company, 915 Main Street, Dubuque, Iowa. Price $2.25, Cloth $3.00.

THE WORKS OF ARCHIMEDES, Edited by F. L. Heath. Paper. Pages clxxxvi +326+51. 12×20.5 cm. Dover Publications, Inc., 1780 Broadway, New York 19, N. Y. Price $1.95. Cloth $4.95.

A HISTORY OF ASTRONOMY FROM THALES TO KEPLER, by L. E. Dreyer. Second

Edition. Paper. Pages x+438. 12×20.5 cm. 1953. Dover Publications, Inc., 1780 Broadway, New York 19, N. Y. Price $1.95. Cloth $3.95.

PROBLEM BOOK IN THE THEORY OF FUNCTIONS. Volume I, Problems in the Elementary Theory of Functions, by Dr. Konrad Knopp, *Professor of Mathematics at the University of Tübingen.* Translated by Dr. Lipman Bers, *Associate Professor of Mathematics at Syracuse University.* Paper. Pages viii+126. 13×20.5 cm. 1948. Dover Publications, Inc., 1780 Broadway, New York 19, N. Y. Price $1.25. Cloth $2.50.

PROBLEM BOOK IN THE THEORY OF FUNCTIONS, Volume II, Problems in the Advanced Theory of Functions, by Dr. Konrad Knopp, *Professor of Mathematics, University of Tübingen.* Translated by Frederick Bagemihl. Paper. 138 pages. 13×20.5 cm. 1952. Dover Publications, Inc., 1780 Broadway, New York 19, N. Y. Price $1.25. Cloth $2.50.

ELEMENTARY MATHEMATICS FROM AN ADVANCED STANDPOINT, ARITHMETIC, ALGEBRA, ANALYSIS, Volume I, by Felix Klein. Translated from the Third German Edition by E. R. Hedrick, *Professor of Mathematics, in the University of California at Los Angeles,* and C. A. Noble, *Professor of Mathematics in the University of California at Berkeley.* Paper. Pages ix+274. 13×20.5 cm. Dover Publications, Inc., 1780 Broadway, New York 19, N. Y. Price $1.50. Cloth $3.25

SUBSTANCE AND FUNCTION, AND EINSTEIN'S THEORY OF RELATIVITY. Both Books Bound as One, by Ernest Cassirer. Paper. Pages xii+465. 13×20.5 cm. 1953. Dover Publications, Inc., 1780 Broadway, New York 19, N. Y. Price $1.95. Cloth $3.95.

INSECTS CLOSE UP, by Edward S. Ross, *Curator of Entomology at the California Academy of Sciences.* Paper. 80 pages. 15×23.5 cm. 1953. University of California Press, Berkeley 4, Calif. Price $1.50.

BASIC BODY MEASUREMENTS OF SCHOOL AGE CHILDREN. A HANDBOOK FOR SCHOOL OFFICIALS, ARCHITECTS, AND DESIGN ENGINEERS IN PLANNING SCHOOL BUILDINGS, FURNITURE, AND EQUIPMENT, Prepared by W. Edgar Martin, *Specialist for School Furniture and Equipment, Division of State and Local School Systems.* Paper. Pages vi+74. 20.5×26 cm. June 1953. U. S. Department of Health, Education, and Welfare, Office of Education, Washington 25, D. C.

LEARNING TO USE ARITHMETIC, by Agnes G. Gunderson, *Professor of Elementary Education and Supervising Teaching, University of Wyoming, Laramie, Wyoming,* and George E. Hollister, *Professor of Elementary Education, University of Wyoming, Laramie, Wyoming.* Paper. Book I, 96 pages. 21×29 cm. Price 64 cents. Book II, 144 pages. 21×29 cm. Price 76 cents. Readiness Book, 64 pages. 21×29 cm. Price 52 cents. 1953. D. C. Heath and Company, 285 Columbus Avenue, Boston, 16, Mass.

SOURCES OF FREE AND INEXPENSIVE TEACHING MATERIALS IN SCIENCE, by Hugh B. Wood and Howard Impecoven, *University of Oregon, Eugene, Oregon.* Paper. 9 pages. Price 20 cents.

INFORMAL PROBLEMS FOR NINTH GRADE MATHEMATICS, by V. L. Bartell, *Grant High School, Portland, Oregon.* Paper. 7 pages. Price 20 cents.

A TEST TO MEASURE OBSERVATION AND UNDERSTANDING OF PHYSICAL PHENOMENA AND LIFE PROCESSES, by Annette M. Wright and Hugh B. Wood, *University of Oregon.* Paper. 6 pages. Price 25 cents.

PLASTIC MOUNTS FOR SCIENCE SPECIMENS, by Hiram M. Hunt, *University of Oregon.* Paper. Price 25 cents.

MONEY: A MEANS OF EXCHANGE, by Fern Ray Macho, *University of Oregon.* Paper. 15 pages. Price 20 cents.

WEATHER AND THE WEATHERMAN, by Lowell R. Bee, *University of Oregon.* Paper. 23 pages. Price 40 cents.

BOOK REVIEWS

A SCHOOL COURSE IN MECHANICS, by A. J. Bull, M.A., *Assistant Mathematics Master, Bryanston School.* Two volumes, Part I and Part II. Cloth. Part I—pages vi+156; Part II—pages vi+408. 13.5×22 cm. Part I—1952; Part II—1953. Cambridge University Press, American Branch, 32 East 57th Street, New York 22, N.Y. Price—Part I $1.75; Part II $2.75.

These two books are by an English author and written primarily for use in English schools. Since there is such a difference in the two school systems it is difficult to place where it would be used in our system. Calculus is used in both volumes which would preclude their use in most high schools or junior colleges. Since they deal with theoretical mechanics the texts would probably be used in the sophomore or junior years of college.

Since the reviewer isn't familiar with the English schools the following excerpt from the preface may be of help to the reader.

> "The two parts together provide a continuous course reaching the standards required for the papers at Advanced and Scholarship Levels in applied mathematics in the examinations for the General Certificate of Education. . . . The book has been planned to cover the work required for all Advanced Level papers in mechanics and also to meet the requirements of those candidates taking Scholarship Level papers in what is now termed by some examining bodies Mathematics for Science."

Volume One deals with uniform motion—velocity, acceleration, force, machines, and centres of gravity. Part II deals with non-uniform motion—motion of particles and bodies in planes, simple harmonic motion, and forces in hydrostatics.

The books are excellent reading. The author's use of vector quantities is especially well written and explained. The style of writing is very complete. The formulas are well developed and easily followed. If it has been some time since you had your college work, these books are very interesting reading. To read them seems like you are sitting in the lecture room and Mr. Bull is giving the lecture.

At the end of each chapter are several excellent problems. There is an answer section in the back. In the text proper one or two examples are completely worked after each formula is developed.

E. WAYNE GROSS
University School
Bloomington, Indiana

SCIENCE IN DAILY LIFE, by Francis D. Curtis, *Professor of Education and of the Teaching of Science, University of Michigan,* and George Greisen Mallinson, *Professor of Psychology and Science Education, Western Michigan College of Education.* Cloth. Pages xii+570. 7×9 inches. 1953. Ginn and Company. Price $3.96.

The style, layout and content of this ninth grade general science text will interest every general science teacher. The extensive use of color, even on the line drawings helps make it a very attractive and interesting book.

Both authors are noted for their studies in science education. Both have also been classroom teachers of general science. Dr. Curtis was a member of the committee which published the *Thirty-first* and *Forty-sixth Yearbooks* of the National Society for the Study of Education.

The text consists of fourteen units. As you read the table of contents only two of the units have titles indicating they deal with biological sciences. However, many of the sub-topics in the other units are concerned with human life, and plants and animals. For example, Unit 4—The Nature and Importance of Weather and Climate, would seem to be of a physical science nature. But, one of the two chapters deals with climate and life.

The form of each unit is as follows. Each unit is introduced with a full page picture. These are well selected and the caption asks a question. Each unit consists of one to four chapters. These are divided into several sub-topics with bold-face type sideheads. The end-matter of each chapter consists of *Checking What You Know* (this is in the form of a completion type test); *Scientific Principles* (a summary of important principles in the chapter); *Scientific Terms* (list of new important terms used in the chapter); and *Applying and Extending What You Know.*

This last mentioned part is another unique part of this text. In the end matter of the book are two pages discussing the scientific method and scientific attitudes. Then each unit has two or more practical situations in which these attitudes and procedures are used and discussed. Here also the questions are in the form of application questions. This is consistent with the author's aim of making general science more than a collection of facts. The experiments, projects and reports are also listed in this section.

There are some points you as a teacher will want to check as a prospective user. Do you like the use of footnotes? The pronunciation of all difficult words is in footnotes. There is hardly a page without one or more footnotes. Do you like cross-references, both backward and forward in the text? Many such footnote references are used. Do you like asterisks, letters, and daggers in the reading material to indicate certain things? These are used to indicate most important material, principles, and lesser important words. Will the cover retain its new beauty after use?

This book is new in many respects. If you are a general science teacher, you should become familiar with this book.

E. WAYNE GROSS

GENERAL TRADE MATHEMATICS, Edwin P. Van Leuven, *formerly of the Department of Mechanical Arts, Bakersfield High School and Bakersfield College, Bakersfield, California.* Pages viii+553. 1952. McGraw-Hill Book Company, New York, Price $3.80.

The book is a revision of the 1942 edition by the same author. He has eliminated little used material, added new topics, added to some sections, and brought price and wage changes up-to-date. The chapter on vocational finance has been changed to conform with new laws and regulations and has been extended to include income taxes and take home pay.

The first six chapters cover a complete review of the fundamental operations of arithmetic and percentage. The text covers the content usually found in books on shop mathematics and ends with chapters on mechanics, electricity, machines, and efficiency. The chapters are sufficiently independent in presentation of material that any sequence desired may be followed.

The explanations are written for and to the student in order to make a minimum of help from a teacher necessary. Over 150 exercises are explained in boxed examples for easy reference. Exercises and problems for practice are abundant. There are over 3000, and most of them are selected from shop situations in order that the student may become familiar with each usage. Tables needed for reference are given in the back of the text.

The book is intended for use as a text in classes in mathematics for industrial and technical schools. It can also serve very well as a book for home study and as a reference work. It deserves a careful examination by anyone looking for a text in trade mathematics.

G. E. HAWKINS

ARITHMETIC FOR HIGH SCHOOLS, Charles H. Butler, *Head of Mathematics Department, Western Michigan College of Education, Kalamazoo,* Pages xv+336, 1953. D. C. Heath & Company, Price $2.40.

This text is intended for use by high school pupils as an aid in extending their understanding of arithmetic and in rebuilding skill in computation. Two phases of arithmetic are emphasized, the manipulation of symbols or skill in computation and understanding of number and measurement. Skill and understanding are interactive, and the author has used each aspect to reinforce the other.

The topics covered include the nature of arithmetic, the fundamental operations with integers, common fractions and decimals, ratio and proportion, percentage, squares and square root, formulas, measurement, perimeters, areas, volumes, and vectors. The author carefully explains and illustrates each process, then furnishes exercises for drill and problems. Rationalization of each process is used, and for the high school pupil with added maturity a study of these explanations should definitely throw new light on his understanding of the processes of arithmetic.

This text is one of the few texts in arithmetic prepared especially for high school pupils. The author and publishers are to be commended for making it available. It deserves careful examination by high school teachers looking for a text in arithmetic.

G. E. HAWKINS

MATHEMATICS OF FINANCE, by Lloyd L. Smail, *Professor of Mathematics, Lehigh University.* Pages x+282. 1953. McGraw-Hill Book Company, Inc., 330 West 42nd St., New York 36, N.Y. Price $4.50.

This book is a text for college classes in mathematical methods in finance and investment, particularly for students in business administration or commerce. The topics covered are those usually found in such a course. Annuities are treated in two chapters, the first dealing with the case where interest-conversion period and payment period coincide, the second with more general cases. Life annuities and life insurance are treated briefly.

The text has several desirable features. New terms are carefully defined, and new principles are carefully developed with adequate explanation and illustrated with examples. These principles are expressed as formulas whenever possible. An adequate number of carefully graded problems and exercises follow each section. Answers to odd-numbered exercises are furnished in the back of the book. At the end of each chapter is a list of review exercises, and the last chapter contains an extensive set of supplementary exercises. Necessary tables are provided in the back of the book. The text deserves careful examination by instructors choosing instructional materials for Mathematics of Finance.

G. E. HAWKINS

THE PRINCIPLES OF LINE ILLUSTRATION, by L. N. Staniland, A.R.C.S., D.I.C., A.R.W.A. *Long Ashton Research Station near Bristol, England.* Cloth. xii+212. 14.5×22.0 cm. 1953. Harvard University Press, Cambridge 38, Mass. Price $5.00.

In *Principles of Line Illustration* this English Entomologist and Painter proposes to demonstrate that students and research workers may acquire adequate skill for making drawings both for their own information and for use in reproductions in their publications. He restricts his attention, however, to LINE drawings leaving other and more costly methods of illustration for others to treat.

The author says, "Anyone, with practice and care, can make an accurate drawing. . . . Aids to drawing are described in this book. . . . Scientific workers . . . may unhesitatingly use aids . . . to save time and promote accuracy."

As would be expected, the book is generously illustrated by more than 160 line drawings. He promises, "This book is designed for biological workers (but)

it should also prove helpful to those interested in other branches of science."

Chapter headings, in order, are: Techniques; Aids to accuracy; Use of colour; Graphs, diagrams and maps, and Some help with lettering. An appendix of nineteen pages headed, Mints and tips, a brief Summary and a two page double columned index complete its contents. The reviewer, even though a chemist, sees much in the book that is both attractive and useful for his students.

B. CLIFFORD HENDRICKS,
457 24th Ave.
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FRENCH INVENTIONS OF THE EIGHTEENTH CENTURY, Selby T. McCloy. Cloth. Pages viii+212. 15×23.5 cm. 1952. University of Kentucky Press, Lexington, Ky. Price $4.50.

The author, an historian, found the publicity of France's inventive activity, during the period when the British were staging their Industrial Revolution, inadequate. The insufficiency was evident in the publications of both the French and the English press. In the volume, here considered, he proposes to help correct that deficiency.

In twelve chapters, plus an introduction and a conclusion, he tells of the French beginnings of: ballooning, steam transportation, telegraphy (not electric), lighting, paper making, textiles, military and medical inventions. He briefs research in chemistry, for the 1700's, under the title "Chemical Inventions." One chapter, "Automata," presents an interesting account of robots of French design. (These, certainly, had little to do with France's belated Industrial Revolution.) The plan of presentation is that of anecdotal narrative. For a scientist that style would have been greatly enhanced had more statements been made explicit. In parts of the book, in which evaluations are assayed, such adjectives as "colossal," "glorious," "dazzling" and "enormous" are used too frequently to inspire confidence in the appraisal. It has been said the "science and technology have an international history" and therefore that aspect of a nation's culture must be integrated into that of the world picture. Dr. McCloy does not do that appreciably in this book. He may reply, with reason, that to do so would have expanded the number of pages to unwieldy dimensions. Perhaps it should also be remarked that had the author-historian used a jury of scientists and industrialists to referee his selection of topics for inclusion the treatment emphasis would have been less spotted. Even so, it is gratifying to have this story in English. Attention should be called to an excellent bibliography and an ample index for the reader who is also a student.

B. CLIFFORD HENDRICKS

THE RADIO AMATEUR'S HANDBOOK. (THE STANDARD MANUAL OF AMATEUR RADIO COMMUNICATION.) 30th Edition, by Headquarters Staff of the Radio Relay League. Paper. 799 pages. 16×24 cm. 1953. American Radio Relay League, West Hartford, Conn. Price $3.00.

This book is published for use of amateurs but has come, in the twenty-seven years of its publication, to serve a wider public including engineers, educators and military as well as agencies for installation and servicing radio. Especial attention has been given, in this volume, to the chapter on measurements, featuring both equipment and techniques for accurate check on the performance of the station equipment. In twenty-five chapters attention is given to: electrical laws and circuits; vacuum tube principles; high frequency receivers and transmitters; power supplies; modulators; antennas; ultra high frequency; mobile equipment; assembly, construction and operating a station, etc. Miscellaneous and vacuum tube data require seventy of its pages and the catalog section spreads over 180 pages. A twelve page double columned index caters to its ready use by its busy owner. Surely every "radio-ham" will want a copy of this encyclopedic reference book.

B. CLIFFORD HENDRICKS

ALONG THE GREAT RIVERS, by Gordon Cooper. Cloth. 159 pages. 13.5×21.5 cm. 1953. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $4.75.

This is a series of interesting stories by the great traveler, Gordon Cooper, who has been nearly all over the earth. From each continent he picks the most important, or the most interesting rivers from his viewpoint, and tells of the rate of flow, cataracts and falls, scenery, navigation, sediment carried, and of the people, culture, and industries along its banks. In Africa it is the story of the Nile, which he lists as the Greatest River, and of the Zambezi; in Asia the Yangtze Kiang and the holy river Ganges; in Australia the Murry with its main tributary the Darling; in Europe the Volga and the Danube; in North America the Mississippi and the St. Lawrence; in South America the Amazon with a greater drainage area than any other two in the world. The appendix gives a table of twenty-eight of the world's greatest rivers, their approximate length and drainage area. This is a book that will appeal to nearly everyone. It is a book of geography, scenery, ancient and modern history, civilization, travel, industry, and of the daily lives of the people.

G. W. W.

SOLID GEOMETRY: A CLEAR THINKING APPROACH, by Leroy H. Schnell, *Scott Teachers College, Indiana, Pennsylvania* and Mildred G. Crawford, *Roosevelt School, Michigan State Normal College, Ypsilanti, Michigan.* Pages x+198. 1953. McGraw-Hill Book Company Inc., New York. Price $3.20.

The authors do not present this book as a sequel to "Plane Geometry: A Clear Thinking Approach," in the usual sense. Much less attention is given to the analysis of the reasoning process and the development of basic methods of proof. Also there is less emphasis on the idea of transfer of geometric reasoning to daily living which was one of the distinctive features of the Plane Geometry Text. This is to be expected when we consider that instruction in Solid Geometry has rather specialized objectives which must involve the mastery of a well defined and rather extensive series of theorems. As the authors point out in the preface, the same amount of attention given in plane geometry to applying geometric reasoning to everyday situations cannot be given in solid geometry. However an attempt is made to give some further practice in this worthwhile educational experience. At the end of several chapters everyday reasoning exercises are given in the "Keep the Iron Hot" sections.

The organization of theorems is a traditional one which provides an orderly and economical sequence of the basic propositions. The first four chapters cover the essential material on lines and planes in space including the dihedral and polyhedral angle. Chapter five deals with loci and projection. Prisms and pyramids are presented in the chapter on polyhedrons where the essential volume theorems are developed through the use of Cavalieri's Principle which is, of course, postulated. Chapter seven deals with cylinders and cones and contains an interesting discussion of conic sections. The last three chapters develop the geometry of the sphere.

Commendable features of the text include: emphasis on student discovery which results from encouraging student to develop proofs independently wherever feasible; the excellent tests and reviews found at the end of each chapter and the careful attention which is given to helping the student to develop skill in three dimensional drawings.

On the other hand, one cannot say that this text supplies the abundance of material necessary to allow the teacher to select whatever is required to meet class needs. Indeed there are sections where some teachers might find it desirable to supplement the problem materials provided. This book, moreover, does not show the effect of classroom experimentation to the extent manifest in its predecessor in Plane Geometry.

The authors and publishers have succeeded in developing a clear cut and

concise presentation of the fundamental theorems including all required theorems listed in the National Committee Report and by the College Entrance Examination Board in a book which is appropriately illustrated and typographically pleasing. This text deserves examination by anyone considering a new text book in Solid Geometry.

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MODERN MARKS WITH MEANING. II

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Marks and marking seem to be a perennial source of torment to students, teachers and parents. In an earlier article[1] the writer described a system of marking something like that described by Billett[2] and referred to by him as the ABCD contract. He sharply criticized it, primarily becauseit stressed the value of marks and gave no recognition to "Educative Growth." It is the opinion of this writer that students, parents and administrators must have marks that have meaning because they are so stressed. It is also possible to adapt the ABCD contract system so that it does recognize "Educative Growth."

The system referred to in the earlier article[1] has been in use for over two years and has proved to be quite successful. It does fail to recognize much of individual differences or "Educative Growth." Since the recognition of these two factors is not only necessary but a recognition of reality, an effort has been made to find a way to do it. If one employs the method known as the ABCD contract as modified and reported in[1] it becomes evident that the student has secured a mark that is equal to his achievement in relation to his classmates. It is a marked base on the workings of democracy and freedom of choice and earned through work accomplished against fixed standards. Thus is is comparable to the reality and fixed standards that the student will face in all walks of life.

What of his native ability? All are created unequal in nature's gifts. Are his achievements in relation to his own handicaps and talents given no consideration? This is what is generally meant by "Educative Growth." It is obtained by securing a raw score on a pre-test at the beginning of the course using a valid and reliable standardized examination and comparing this raw score with the maximum possible score on the same examination. This reveals the maximum Educative Growth potential. Thus:

[1] MacCurdy, R. D., "Modern Marks With Meaning," SCHOOL SCIENCE AND MATHEMATICS, December, 1952.
[2] Billett, R. O., "Fundamentals of Secondary School Teaching," Houghton Mifflin Co., Boston, 1940.

a. Raw Score on the Pre-test	40
b. Maximum Possible Score	150
c. Maximum Ed. Growth Potential	110 (difference b−a)

At the completion of the course the student is again tested (this time as a final examination) on the same test or a companion form. His post-test raw score should be higher than his pre-test raw score. The amount greater is his Educative Growth. This can be easily converted to an "Educative Growth Percentage" and thus to a letter grade of ABCD or F by dividing the Educative Growth by the maximum Educative Growth Potential. Thus:

1.	d. Raw Score of the Post-test	135
	a. Raw Score of the Pre-test	40
	e. Educative Growth	95 (difference d−a)
2.	e. Educative Growth	95
	c. Maximum Ed. Growth Potential	110
	f. Educative Growth Percentage	86% or B (divide e by c)

Now we have two marks for the student in the course. One, his achievement in relation to others with fixed standards. The other, his achievement in relation to himself with personal or individual standards.

Wherever possible it is desirable to report as a fraction the student's final mark with the numerator his "social" mark and the demoninator his "individual" grade thus: C/B. Whenever it is necessary to report the final mark as one letter a compromise letter can be selected that reflects both. Thus:

$$\frac{C \text{ ("Social Achievement)}}{B \text{ ("Individual" Mark)}} = B-$$

The last or compromise mark can be called the Life Value Mark.

TWO MILLION ENROLLMENT INCREASE

Schools and colleges during the 1953–54 academic year will enroll the largest number of pupils and students in history—36,949,700. This is about 2 million more than last year.

Public and private elementary schools will enroll 26,931,000 children, as compared with last year's 25,349,000. More than 3,000,000 will enter the first grade.

Secondary schools, both public and private, will have 7,302,000 students. Last year there were 7,028,000.

College-university enrollments this year will be 2,500,000. In 1952–53 they totalled 2,400,000.

By 1960 it is estimated that there will be 10 million more pupils and students in our Nation's schools and colleges, both public and private, than there were last spring.

This fall the United States will be short about 345,000 public elementary and secondary school classrooms. Three classrooms out of every five will be overcrowded. One out of every five pupils will go to school this coming fall term in a schoolhouse which does not meet minimum fire safety conditions.